THE ESTATE OF MAN

by the same author

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THE MODERN MIND

ORION MARCHES

T. E. HULME

THE RECOVERY OF THE WEST

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THE FABER BOOK OF MODERN VERSE

Editor

THE FABER BOOK OF COMIC VERSE

Editor

THE
ESTATE OF MAN

by

MICHAEL ROBERTS

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FOREWORD

Michael Roberts died in December 1948, leaving seven completed chapters of *The Estate of Man*, on which he had been at work from the autumn of 1946 till within three months of his death. Of these chapters, I, II and IV had been thoroughly revised by himself; Chapter III, on Forests, was to have been expanded. The three other chapters had been rewritten more than once, but it is probable there would have been further revision of them. He left some notes for the projected Chapters VIII and IX; these are printed as Appendix A. Three pages of notes which he intended to work into an Introduction are printed at the end of this Foreword.

Clearly, there would have been further alteration and revision if he had been able to complete the book: on grounds of style and arrangement, and because of the need to take recent developments into account. But it seemed better to alter what he had written as little as possible. Michael Roberts was a poet, a mathematician, a philosopher and a teacher; both the unity and the diversity of his mind are reflected in the conception of the book, and in its carrying out. For another person to make substantial changes, even by adding material interesting and relevant in itself, would be to risk destroying the balance of the book—where physical, intellectual, mental and moral problems are held in one view—which was an essential part of its conception. So the text is substantially as he left it (though I was tempted to work in some of the remarks I found here and there in the files—'Arab proverbs are not evidence' or 'A million loonies can't be wrong'). But the facts and figures have been checked throughout—and here I most warmly acknowledge the help given me by Marjorie Deane and Barbara Katz of *The*

Economist Intelligence Unit—and where necessary as a result of this, very slight modifications have been made in the text; not more than a hundred lines have been affected. Originally, all the tables were in the body of the text; in deference to the general reader, those that did not form an integral part of the argument have been relegated to Appendix B.

I acknowledge with gratitude the help of Mrs. Honor Croome, Miss H. M. Gooch, Miss Elizabeth Monroe, Miss Christine Reynolds and Mr. T. W. Eason in preparing the manuscript for press, and in reading the proofs. For assistance on specific points I should also like to thank Dr. G. R. Crone, Librarian of the Royal Geographical Society, Dr. P. Dunsheath, Dr. Balfour Kirk, Mr. T. Lindsay, Sir William Ogg and Sir George Thomson.

JANET ROBERTS

NOTES FOR AN INTRODUCTION

There are about 2,350 million people in the world, and the number is increasing at the rate of twenty million a year; the world's land area is about 56 million square miles, but the fraction which can be made to yield food is much smaller, and is, in fact, diminishing through erosion and the exhaustion of the soil. Plainly a time will come when any further increase in population will result in a decrease in rations for everyone.

In spite of all this, and in spite of recent hardships, we often talk as if we had an inexhaustible reservoir of material and skill: we overlook the limitations of our resources—moral and intellectual as well as material—and we sometimes fail to recognize the limits of man's capacity to adapt himself to the conditions which he has helped to create. The object of this book is to inquire into such limitations. We are not concerned with politics, but with the conditions within which any far-sighted political policy must be framed.

The main questions which I have tried to examine are these: what are our total available resources in terms of material, population and skill; to what extent are these resources likely to increase or decrease in the near future; what limits are there to the natural productivity of the soil; and what limits are there to the adaptability of man.

Once these questions are answered, even if the answers are only tentative, we can apply a proper test to all proposals for new forms of production and for new forms of labour: 'What are you doing this *instead of*?' The resources at our disposal are great, but they are not infinite: if we use a field, or a piece of coal, or a man's skill, for one purpose, we cannot use it for another. So

often we are told that a nation needs a hundred thousand more civil servants, eighty thousand more teachers, fifty thousand more miners, and such claims are accepted without anyone asking whether it is proposed that the total population shall be increased or whether it is being suggested that people should be transferred from other occupations.

The present age seldom looks beyond one generation: we build for own lifetime or even less, we do not build for our children and grandchildren. We use the resources of the earth to gain a quick profit, no matter what ruin we leave behind. We construct political and economic systems which are intended to stamp out the old habit of trying to hand over to one's children a healthy farm or a thriving business. We are determined that all children shall start as nearly equal as possible. That may be a sound moral aim, but if so, the old habit of thinking in terms of three or four generations must be transferred from private affairs to public.

Pattern of the Book

The common theme is good husbandry, first in material resources, then in man-power, and lastly in our own inner powers. In each of these, there is the lyrical side—the grandeur and beauty of the estate—there is horror at the devastation already wrought, and there is apprehension for the future. But each of the three sections has its own character and poses its own problems.

The fourth section brings all three together, the resolving factor being the need to live in harmony and equilibrium with nature, which is the essence of good husbandry.

CHAPTER I

FOOD AND PEOPLE

If all the 56 million square miles of the earth's land surface were shared out equally among its 2,350 million people, we would each have about 15 acres, including roughly 5 acres of jungle, or forest, about 4 acres of dry desert, another 2 acres of semi-arid land and 2 acres of polar snow. Beneath the ground of each man's estate there would be 3,000 tons of coal and about 5 tons of petroleum.

The average citizen of Great Britain or the United States makes considerable demands on that small fraction of the estate which is under cultivation. He consumes over 200 lb. of wheat, about 200 lb. of potatoes, and about 85 lb. of sugar every year. He eats 100 lb. of meat and 20 lb. of fish. He imports vast quantities of semi-tropical fruits and products such as tea and coffee from the outlying parts of the estate. To supply an inhabitant of the United Kingdom with his normal diet, requires about 3 acres of pasture or cultivated land; to supply a citizen of the United States, about 4 acres are needed. In Japan, the area of land available for cultivation is less than a third of an acre per person. Over the world as a whole, the area actually cultivated amounts to just about one and a half acres per person.

A century ago, the estate would have been twice as large; there would have been a bigger proportion of forest and the ploughland would have been in better condition. There would have been rather more coal underground and a good deal more petroleum. What will conditions be like in a hundred years' time? As the world's population increases, so each man's plot of land dwindles. At present, the number of people in the world is

increasing at the rate of about twenty million a year, which means that each of us is losing an acre every ten years. We can make up for this loss only by growing more on our small plot of cultivated land or by turning more of our waste land or forest into ploughland or pasture, as we have been doing for three or four generations. Plainly, the process cannot be continued indefinitely: some of the land is hopeless, some of the forest is needed for timber, some is needed to protect the soil from wind and flood. Hitherto, the world's food supply has kept pace with man's increasing numbers: how long can the process continue?

How many people can the world feed?

There are four times as many people in the world as there were in 1650, and the world is producing about four times as much food. We have grown so used to continuous and parallel expansion of population and food supply that we find it hard to think that the difficulties of recent years are anything more than temporary setbacks. Malthus, with his grim doctrine that people tend to multiply faster than crops or cattle, was proved wrong, so far as the nineteenth century was concerned. Throughout that century, populations multiplied, but overseas there were always new forests to burn and new fields to plough; and after 1850 the expansion of population began to slow down where it had started—among the peoples of western Europe. But will the people of Africa and Asia show the same good sense when every one of the world's fifty-six million square miles of land is yielding its maximum harvest? And how fast are we approaching that critical date?

The world's main crops

Wheat and rye, oatmeal and potatoes, maize, rice, barley and millet are the staple foods of mankind, and so long as ample supplies of these are available, the world can at least avoid starvation. Statistics are none too reliable, and in the early years of the century the official estimates were almost certainly too low; nevertheless, it is possible, with patience, to compile figures for rice and the five main cereals which are almost certainly accur-

ate to within.2 or 3 per cent, and these may be compared with the accepted estimates of the world's population.

WORLD CROPS
(In millions of long tons per annum)

Period	Wheat	Rye	Barley	Oats	Maize	Rice	Total	World's Popn.	Tons per head
1901–5	87	38	26	51	82	100?	384	1645m.	·234
1906–10	90	40	31	56	96	110?	423	1711m.	·247
1911–15	104	43	38	64	105	118	472	1779m.	·265
1916–20	91	26	29	59	103	125	433	1844m.	·235
1921–25	99	40	32	59	104	132	466	1915m.	·243
1926–30	118	43	39	69	105	133	507	1987m.	·255
1931–35	119	42	39	63	107	140	510	2057m.	·248
1936–40	151	43	51	65	120	141	571	2140m.	·267
1941–45	150	37	47	60	129	137	560	2245m.	·249
1946	155	36	45	57	132	140	565	2295m.	·246
1947	155	38	47	53	121	146	560	2315m.	·242
1948	172	42	51	60	151	153	629	2350m.	·268
1949	168	43	48	57	140	153	609	2375m.	·256

Of course, such a table does not tell the whole truth, but it does give a fair idea of the general trend. Millet, which is omitted from the table because no satisfactory estimates are available for the earlier period, is a minor crop, amounting to less than 10 per cent of our total; potatoes are far more important and must be considered separately. The fact that much of the world's barley, oats and maize is fed to domestic animals makes little difference to the picture, for these domestic animals are themselves part of our food supply. The inclusion in our total for the world's population of people such as the Eskimos, with their strictly carnivorous diet, and the tribes of the tropical Amazon basin, with their curious passion for crude tapioca, does little to vitiate the result, for so far as one can tell the fraction of the world's population which does not rely on any of the crops

given in our table has remained fairly constant during the past fifty years.

Turning back to the table itself, we see that in 1946 and 1947, the world could afford rather less rice and cereals per head than in 1911-15: the development of irrigation, the improvement in strains, the intensified use of artificial fertilizers and a large extension of the area under cultivation, all these had been swallowed up in the great increase in population. On the other hand, the yield per head had not seriously decreased. Indeed, if potatoes are taken into account, the available ration had actually increased, for the cultivation of potatoes increased rather faster than the world's population. The difficulties of 1946 and 1947 were not due to inadequate crops, but a number of causes, including the tendency of some of the major producers to keep more of their crops at home to feed their own people. The failure of the world's supply of rice to keep pace with the very rapid expansion of the Indian and Chinese population obviously intensified the difficulties of importers, who now had to compete with India and China in the world's grain markets. Again, during the war the world had eaten up most of its normal reserves, and by 1947 it had no stocks left to help tide over a bad or indifferent harvest.[1]

The position had, in fact, become extremely precarious: the high standard attained in the previous ten years had been largely due to a series of exceptionally good seasons in the Northern Hemisphere, and the world as a whole was living beyond what it could safely regard as its normal income. The reserves had vanished; and for six or seven years, the world's farmers had been straining every muscle to tear the largest possible crop out of their land, even to the detriment of the soil. The land, if not the farmers, needed a rest. The world, in 1947, was in no condition to face a break in its run of good fortune, and the situation was rendered the more delicate by increased reliance on the

[1] In a sense the position has improved, and there was a surplus of wheat for sale in 1949 and 1950. But this is not really a physical surplus: the world is not producing more wheat than its inhabitants could eat; only, more wheat is being produced by dollar countries than other countries have dollars to buy.—*J.R.*

potato, a notoriously temperamental crop and one which cannot be stored for more than nine months.

And yet, within ten or twelve years, there will be 200 million more people to be fed. There is no reason to suppose that up to the present the world's population has seriously overshot the world's supply of food, but when we remember the strenuous effort which farmers have had to make in recent years, we are compelled to reflect that it may be very difficult indeed to increase the world's output of food by another 10 per cent. If that is so, any further expansion in population will place a heavy strain on the world's larder, or at any rate on its flour-bin and potato-sack.

So long as other foods are available, a reduction in the supplies of wheat and rye, oatmeal and potatoes, barley, maize and rice, would not necessarily lower the standard of living. The housewife who uses a vacuum cleaner instead of a broom, and the ploughman who drives a tractor instead of walking the furrow, need less calories (and therefore less cereals) than their ancestors. They are likely to eat less bread and more fruit. In Great Britain, between 1905 and 1925, the consumption of bread per person was slightly reduced, but people ate more cake and sugar, as well as 20 per cent more butter, 50 per cent more fruit and over 100 per cent more margarine. Similar changes took place in Germany and the United States. Just before Hitler came into power, the average German was eating 20 per cent more butter and sugar than in 1913 and 30 per cent less rye and potatoes.

In general, however, changes of this kind do nothing to reduce the total cultivated area necessary for each person: they merely make it possible for the citizens of the temperate zones to live more and more on the produce of land in the tropics, land which is in any case unsuitable for the cultivation of cereals. If the world is to support an even larger population than at present, still more changes of this kind will be necessary, if only to counterbalance the increasing tendency of sub-tropical India to import grain from Australia or Canada.[1]

[1] See Appendix B, Table I: Continental Shares in World Production.

There are, however, limits to the changes which are possible; a diet of tropical fruit is not much use to the Pittsburgh steelworker or the South Wales miner; and wheat, oats and rye are likely to retain their places in the diet of the white races. Wheat is of crucial importance: it is the staple food of nations such as Britain and Belgium which depend largely on imported grain; it is the alternative to which the Asiatic countries turn as they outstrip their own supplies of rice; and the difficulties which must be overcome in the attempt to grow more wheat are closely similar to those which hinder our efforts to extend the cultivation of barley, oats and rye.

Wheat

At the beginning of the present century five countries overshadowed all others as producers and exporters of wheat. The countries of Western and Central Europe produced, and still produce, as much wheat as Canada and the United States combined, but most of their produce was consumed at home, and only the North American countries, together with Australia, Russia and the Argentine, played any large part in the international trade. In each of these five countries, production has increased; in Russia it is still steadily increasing.[1]

Thanks to the fact that a spell of bad harvests in the Northern Hemisphere is often balanced by good harvests in Australia and the Argentine, there has been a fairly steady increase in the world's annual total, and one might reasonably expect the total to increase still further, for when the expansion slowed down in the early nineteen-thirties, the primary cause was not a shortage of land but an accumulation of stocks and a falling-off in demand.[2] The white population of the world was not increasing as fast as it had done in the early part of the century, the unemployment caused by the 1931 slump resulted in empty purses

[1] See Appendix B, Table II: Wheat, Average Annual Production.

[2] World stocks on 1st August 1931 were estimated at 904 million bushels; the average on the same date for 1924–7 had been 493 million. For the American and Australian farmer, the position was worsened when Russia, which had exported practically nothing in the twenties, suddenly exported 77 million bushels in 1930 and 88 million in 1931.

and poorer appetites, and the increase in skilled work or light manual work as compared with heavy manual work had produced a change in tastes. Farmers, in 1932, found themselves with stocks of grain they could not sell, and so they deliberately refrained from increasing the area devoted to wheat.

The fact that the halt of the early thirties was deliberate should not, however, blind us to the reality that the area devoted to cereals is already approaching the maximum. Even when the demand for wheat has been heavy, farmers have not been able to increase their acreage as fast as they did in the years before 1914.

A more immediate difficulty, however, arises from the fact that in some of the exporting countries, the population is increasing faster than the annual production of wheat. The number of people in the United States increased from 76 millions in 1900 to 139 millions in 1945, and in the same period the population of the Argentine increased from under five millions to 15 millions. In consequence more wheat was retained for domestic consumption and the amount for export has decreased.[1]

By 1940, the United States, at one time the greatest wheat-exporting country in the world, had become a buyer rather than a seller, and only the sacrifices of her people, the strenuous efforts of her farmers, and a succession of remarkably favourable seasons, enabled her to send great quantities of wheat overseas in the years following 1945. Russia, since the Revolution, has exported very little and has been a most erratic seller, exporting virtually nothing in 1928 and 1929, then 77 million bushels in 1930 and 88 million in 1931, and very little in the years that followed. The progressive decrease in Australian exports in the years from 1936 to 1947 was probably temporary, for it was due mainly to a series of bad harvests; but bad harvests account for only a part of the decline in Argentina's exportable surplus: the greater part has been due to an increase in domestic consumption.

More important than all these individual changes is the fact that the total amount of wheat for export declined from 767

[1] See Appendix B, Table III: Net Exports of Wheat and Flour.

million bushels a year in the late twenties to under 500 million bushels in the early forties.[1] In the early thirties, farmers were naturally anxious to avoid the over-production which led to the slump in 1930, but since then prices have practically doubled; and yet in 1947 farmers were only just able to meet the world's demands. The war is certainly responsible for some of the deficiency, but the difficulties of increasing the production of wheat seem to go deeper: the farmers, even when labour, machines and fertilizers are available, seem to be finding it difficult to keep pace with the expansion of the world's population. No doubt a further effort can be made; and if the price of wheat is stabilized on a level (relative to industrial goods) higher than that of twenty years ago, land which has hitherto been regarded as too poor to cultivate will become profitable, and labour will be attracted from the industrial towns to the farms; but it is doubtful whether the net result of such a change can be called a rise in the standard of living, and meanwhile countries such as Britain (with her steady demand for 200 million bushels a year) and France, Italy, Belgium and Holland (each of which need between 25 to 40 million bushels) will have to compete with the increasing demands of China, India and Brazil. Forty years ago, one could contemplate with equanimity an annual increment of ten million in the world's population; to-day, one is compelled to ask whether agriculture can be extended fast enough to keep pace with such a rate of increase.

Other Foodstuffs

The problem in relation to butter, cheese, meat and fruit is not radically different from that of wheat or maize. The difficulty is to find more land suitable for cultivation or pasture. Between 1900 and 1948, the total number of cattle, sheep and pigs in Canada, Australia and the U.S.A. increased by 20 per cent.[2] In the same period, the human population of those countries increased by 96 per cent.

[1] Reference to Table III, p. 143, shows an improvement in the wheat export position since these lines were written; it is too early though to say how permanent the improvement is.—*J.R.*

[2] See Appendix B, Table IV: Livestock.

To a considerable extent, the use of land for pasture or cultivation is interchangeable; but good land will feed more people if it is cultivated as a wheatfield than if it is used for grazing. It follows that if food becomes scarce, pastureland will be ploughed up and sown with wheat or rye or maize. Pigs, in so far as they feed on grain crops which might be consumed directly by human beings, will be neglected. A decrease in the world's livestock is therefore likely to be the first sign of a real shortage of food, though the attempts of governments to control the price of grain are likely for some time to mask the natural symptoms. If farmers cannot make so much money by selling their grain for human consumption as they can by feeding it to their cattle in order to provide meat or butter for wealthy nations or individuals, the poorer people will be lucky if they get the husks.

For a time, the world could feed a bigger population by neglecting pastoral farming where necessary and concentrating, so far as possible, on the production of grain for human consumption. Such a policy would, however, be short-sighted. Although there is a great deal of pastureland that could be used for arable farming, much of it would rapidly deteriorate if it were ploughed up and crops were extracted from it year after year without intermission. There are, indeed, many acres of land under cultivation to-day which need a spell as pastureland if they are to recover their original fertility. Here and there are new areas that can be used for crops or pasture, but a large-scale ploughing up of the present pastureland in order to postpone the crisis would merely lead to a worse crisis in ten or twenty years.

To some extent, the people of the temperate zones can supplement the yield of their own land by means of tropical and semi-tropical products. In the tropics, land that cannot be made to yield staple foods such as rice or maize can nevertheless produce bananas or oranges, and if we regard the whole earth as a unit it is obviously sensible to make the corresponding changes in diet, more especially as those changes seem to suit the change from heavy manual labour to lighter but more intellectual activity. Something might also be done by using synthetic fibres in place of cotton and devoting the cotton-fields to food, as was

done in Egypt during the war. An instance of the opposite trend is the attempt of some temperate countries to become self-sufficient in sugar by growing sugar-beet on land well suited to other root-crops such as turnips, whilst allowing large cane plantations in the West Indies, unsuited for other crops, to go to ruin. The relative abundance of sugar at a time when other foods are scarce is largely due to this remarkable perversity. One ingenious device for supplementing the products of the temperate lands is the cultivation of monkey-nuts (groundnuts) in the tropics. If this were successful on a really large scale, it would reduce the demand for butter and therefore ease the pressure on the grasslands of Europe and North America. Whether it is better for the world to have four people fed on bread and butter or five people fed on bread and margarine is one of those major questions which the human race prefers to decide without conscious thought.

A radical change which would relieve the pressure on the land would be an increase in the consumption of fish. At present, about 20 million tons of fish are caught every year, and the greater part of this is used for human food. The consumption of fish, however, varies very widely from one country to another: some nations eat enormous quantities, others very little. If the consumption of fish were doubled, it would relieve the world of the necessity of fattening (say) 300 million sheep or 100 million cattle. Whether the world's fisheries would stand this strain is doubtful. Fish are prolific creatures (the virtual extermination of the unprolific whale in some areas proves nothing) but fish need food no less than sheep, and the annual removal of an additional 20 million tons of organic matter from the sea might ultimately prove to outweigh the sea's annual gain of waste from the land. There are already local signs of shortage: the cod-fisheries of Newfoundland no longer give as good a haul as they did forty years ago. The matter is one which will have to be investigated as the world's population comes nearer and nearer to the maximum that can be fed.

The British Problem

In no country in the world is a general shortage of food likely to be felt so acutely as in Great Britain. Britain is a great agricultural country, employing more than twice as many farm workers as Australia, and rather more than Canada,[1] and the cash value of her produce is proportional to the number of workers. Only in New Zealand and Australia is the value of produce per worker higher than in Britain. In the U.S.A. it is £185 per worker against Britain's £200.[2] In Denmark, it is £155, in Canada £135. In Belgium, Switzerland, France and Germany the value of the produce per worker is a half or less than a half that of Britain.

The high efficiency of the British farm worker has been due to three factors: a willing and skilful use of machinery wherever this can be used with advantage (in 1947, British farms used 1½ h.p. per worker), a wise concentration on the fattening of cattle, and lastly the good husbandry of the British farmer himself. In a country in which agriculture is carried on as intensively as in Britain (the average yield of wheat per acre in Britain is nearly three times that of the United States) it is essential that there should be a proper rotation of crops, and of cropping and grazing. Britain's pre-war annual import of five million tons of animal feeding stuffs enabled her to keep her land in good heart.

Yet Britain, even when feeding badly and striving to extract the largest possible crop from every acre, has never in the last century managed to provide more than 50 per cent of her own food. To maintain anything like this percentage will be exceedingly difficult. The land is already being driven hard, and if the soil is to be driven harder without receiving the residues of imported foodstuffs which formerly reached it as animal manure, it will soon decline in fertility. Lime and phosphate will help, but it will be very difficult indeed to make up for the gradual

[1] Australia, 470,500; Canada, 1,244,000; United Kingdom, 1,250,000.

[2] Pre-war figures. It has not been possible to get reliable post-war figures, but such information as is available suggests that the relative positions remain substantially unchanged, except that the U.S.A. has probably drawn ahead of Britain.—*J.R.*

loss of 'trace' elements and the more subtle damage to the structure of the soil that comes from over-cropping. In the long run, there are only two solutions for Britain: on the one hand, a reduction of population to half her present numbers, and on the other hand an international food policy. And with the second there would have to be an international population policy.

If Food is Scarce, Who will Get It?

The expansion of population does not automatically stop when food supplies cease to expand. Under the British administration in India, farming methods were improved, new varieties of seed were introduced, and great schemes of drainage and irrigation were initiated. For a time, the standard of living improved, but that improvement was rapidly overtaken by the increase in population. By 1937, the average Indian was getting less to eat than he had had twenty years earlier, and India had become a customer for the world's exports of wheat. In India, there is no question of dividing an increment in the country's production between an increase in population and a rise in the standard of living: in the shortest possible time, the increment is wholly devoted to an increase in population.[1]

Over the past two hundred years, the European races have multiplied their numbers by five, the Africans have nearly doubled their numbers, the Asiatics have nearly trebled theirs. The world to-day supports three times as many people as it did in 1750. All this has resulted, not only from the colonization of new territory, but also from great advances in engineering and in agriculture itself. To-day, if we may judge from the figures of crops harvested, the territorial advance is nearing its end, and the prospects of further advances in the technique of farming are not infinite. Nevertheless, the increase of population goes on with all its old impetus, though to-day it is the Asiatic rather than the European races that are increasing. The F.A.O. Conference which met in Geneva in 1947 found itself compelled to

[1] There have also been some striking and horrifying examples of this development in the West Indies.

assume that within a generation there would be 400 million extra people to feed—mostly in Asia.

Shortage of food will itself, in the end, check the expansion of population. The question is, which peoples will be checked first? Will the British be willing to go short, and even to reduce their own population (through a lowered birth-rate) in order to feed India's prolific millions? Will the Americans do as much for S.E. Asia? And if they do, will they be required to go on reducing their population until they are extinct?

Human nature being what it is, we can assume that the countries which grow their own food will not part with any more of it than they can spare.[1] The countries which will, in fact, suffer first from a world food shortage are the importing countries. It is here that the British have to face a vital question: is Britain an isolated unit, or is it one with the Commonwealth? If the former, it is a food-importing country, deriving more than half its food from overseas. If Britain is one with Canada, Australia, New Zealand and South Africa, then it is part of a food-exporting unit and the only question is what the Home Country can offer the Dominions in exchange for food.

India and Pakistan, if reckoned as part of the Commonwealth unit, are liabilities: Britain would be stronger (in this matter) if she washed her hands of them altogether. This is a brutal way of putting things, but the forces of history are not infrequently brutal, and it may well be that in the course of time the British

[1] H. M. Sinclair in *Thought for Food* (*The Political Quarterly*, January–March 1950), gives some relevant figures.—*J.R.* 'Asia produces 40 per cent of the world's food, Europe 30 per cent, North America 20 per cent, and the rest of the world only 10 per cent. However, less than 5 per cent of the world's land is used for food crops: the percentage in Europe is 20, in North America is 6, in Asia 5, in Africa and in South America 2, and Oceania 1. The annual food production (in lb. dry basis) per acre of land is: Europe 216, Asia 70, North America 66, South America 21, Africa 14, Oceania 10: the world produces about 51 lb. of food per acre of total land annually, or 1,000 lb. per acre harvested. . . . Only 0·7 acres *per capita* is used for food crops, this being distributed as follows: Oceania 2·2, North America 1·7, Africa 1·0, South America 0·9, Europe 0·8, Asia 0·4. . . . Oceania and North America produce more than twice as much food *per capita* as the other areas, the figures being (in lb. dry basis, *per capita* annually): North America 1,980, Oceania 1,910, South America 1,090, Europe 900, Africa 650, Asia 630.'

withdrawal from India will come to be regarded as one of the most astute moves the British ever made.

The American population is still increasing much faster than food production, and the U.S.A. may therefore become a keen buyer in the world's markets. Obviously, she will be particularly interested in Canadian grain. But on the larger issues, the races of European stock are faced with a terrifying question. They alone, of the peoples of the world, are easily accessible to propaganda; they alone have an outlook and a standard of living such that they would sooner reduce their numbers than accept a humbler way of life. The question is whether it is better that three Indian children should die of starvation or that one American child should not be born at all. And if we decide that the proper thing to do is to restrict our own food consumption and limit our birth-rate, are we prepared to accept the progressive deterioration of the world's standards that this would imply?

There is, indeed, no answer, but only a hope. A more careful survey of the world's resources may reveal that there is still a breathing space of a generation or so during which the world's production of food can increase; and during that time Western ideas might so influence the East that even in India the population might be stabilized at something not too far above its present level.

CHAPTER II

THE LAND

The Extent of Cultivable Land

The total area of ploughland in the world to-day amounts to something like 3,000 million acres—about 9 per cent of the land surface.[1] For centuries, the total area under cultivation has expanded step by step with the increase of the world's population. Often recklessly, forests have been burned and turned into pasture, and natural grassland has been ploughed up and sown with wheat or maize, oats or barley. There are signs that to-day, in some parts of the world, we are reaching the limits of possibility, or at any rate, the limits of prudence. It is useless to plough up grassland if the soil is going to blow away within ten years; it is worse than useless to divert a river to irrigate a desert if by so doing we rob a fertile area lower down. Less obviously, but just as surely, it is fatal to cut down the last vestiges of primeval forest if by so doing we expose to wind and flood the land already won.

In Europe, there is virtually no new land to cultivate: life has been hard and pressing long enough to force us long ago to make the most of every fertile acre. Even in North America, there is less scope than is sometimes supposed. In Canada, more than two-thirds of the potential arable land is already cultivated, and what is left is more suitable for mixed farming than for wheat-growing. In the United States, the area under crops could be doubled, but only at the expense of land already used

[1] See Appendix B, Tables V and VI: Land Use and Cultivated Land.

as pasture: there is no 'new land' to cultivate, and the forest area is already too small to serve the country's needs.

Australia, with a total area of three million square miles, has relatively little virgin land. Not more than one-fifth of the whole area could ever be cultivated;[1] the extent of the really good country in Australia is not much greater than that of the British Isles, and of this by far the larger part is already in use. The great inland drainage area centred on Lake Eyre covers an area of nearly half a million square miles. When C. T. Madigan flew over the 'lake' in November 1929, a spear dropped from 900 feet remained standing four feet out of the lake surface: the pilot came down and scarred the dry salt-crust with his land wheels.

Asia, Africa and South America all have large areas on which no useful crop could ever be grown. The rocky plains and salt swamps of the Atacama Desert, the sandy wastes and burning rock of the Sahara and the Kalahari, the vast arid plateaux of Sinkiang and Tibet, are beyond all hope—more than half of the twelve million people of Central Asia live in the oases and there is an area of nearly 400,000 square miles which has no inhabitants at all. In these 'dry deserts' the rainfall is hopelessly inadequate in proportion to the temperature; but in other parts of the world, especially in those where there is no very dry season, excessive rainfall is no less serious a handicap. The peat bogs of north-west Scotland are as much desert as the tundra of Siberia, with its permanently frozen subsoil, or the dry, shifting sandhills of the Gobi.

Taking the world's surface as a whole, Professor C. B. Fawcett has estimated[2] that the areas which have so little rainfall in proportion to their temperature that they must be classed as 'dry deserts' cover twelve million square miles. Another ten million square miles in the polar and sub-polar regions are too cold and have too short a summer ever to bear crops. Of the remaining thirty-four million square miles, about half, or nearly seventeen million square miles, may be regarded as cultivable

[1] C. B. Fawcett, 'The Extent of the Cultivable Land', *Geographical Journal*, Vol. LXXVI, No. 6, December 1930.

[2] C. B. Fawcett, loc. cit.

land: the remainder is forest or damp jungle, waste or high mountain, or at best poor grazing land. For all practical purposes, we may take ten million square miles as the world's present maximum for cultivation and pasture.[1]

It is useless to ask how much land is arable unless we know what kind of people are to farm it, what crops they propose to raise, what return they will expect for their labour, and what are to be their relations with industrial communities. Some of the unploughed land in the United States, Canada, South America and Australia could profitably be cultivated by the Chinese or Japanese peasant, but cannot support the American or Australian farmer with his higher standards. The density of population is often the deciding factor: in the United States, for example, the population might expand by a few millions without any appreciable lowering of standards, but beyond that point the country could support more people only if they were willing to accept a lower standard of living:

'It has been estimated that a population of 150 millions can be cared for without seriously altering our standard of living, by adding forty million acres to our cropped land and improved pasture. Beyond that number of people, both our standard of living and crop yield per acre must be materially altered. If we increase our acre-yield until it equals that of western Europe, and accept the German standard of living, we can provide for 300 million people. It is likely that for many decades the reality

[1] Sir John Russell considered this question in his address to the British Association in 1949, 'World Population and World Food Supplies': 'The world's total land area is 35,700 million acres, but only about 11,000 million are estimated by C. B. Fawcett to be 'climatically suited' to crop growth. Much of this, however, is at present impracticable for cultivation, and the area actually used is some 3,000 to 4,000 million acres: 7 to 10 per cent only of the world's land surface. Some 85 or 90 per cent of this area is used for food production; the rest is for industrial crops. The food producing area represents a world average of about 1½ acres per head which, at British yields, would give the British pre-war dietary; much less would suffice for a vegetarian dietary. The area "climatically suited", however, is about 5 acres per head. Can any of those unused 3½ acres per head be brought into cultivation?' *The Advancement of Science*, Vol. V, No. 23, October 1949.—*J.R.*

will be between these two population estimates, as standards of living and acre-yield slowly change.' At the time when G. J. Miller and A. E. Parkins made this realistic forecast,[1] the population of the U.S.A. was only 123 millions: to-day it is 149 millions.

Too small a population may cause difficulties as great as those caused by a population which is too large. Below a certain minimum, the construction of roads and railways, which are necessary for anything except subsistence farming, is simply too expensive to be practical. If the new land in the northern part of the Argentine Chaco and the southern states of Brazil is to be cultivated, immense numbers of new settlers are needed, and what are needed are practical farmers, not the overflow of city shops and factories.[2]

The area actually ploughed up at present is about four million square miles: to this we must add another four million used as pasture or orchard or plantation. Thus more than half of the world's cultivable land is already in use, and what is left is, on the whole, of quality far inferior to that already in use, and could be cultivated only by workers willing to accept an even lower standard than that of the world at present.

As the area actually under plough and grazing approaches this maximum, the rate of expansion necessarily slows down: the new land is often remote from the centres of trade, or it may need drainage or irrigation, or the soil may be too poor to make its cultivation attractive at the present time. Year by year a smaller area of new land is brought into cultivation.

The difficulty which the great 'new' countries are finding in extending cultivation further is suggested if we consider the rate of increase of their area under cultivation. Between 1900 and 1910, the area cultivated in the U.S.A. increased by 64 million acres; in the next decade 25 million acres were brought into cultivation; then 19 millions; and between 1930 and 1940 only

[1] In *The Geography of North America*. New York, 1934.

[2] By 1937, the north part of the Chaco, and the Brazilian states of Western Parana and Santa Catarina, were the only important areas in the world in which land was available at prices the average immigrant could pay. *International Labour Review*, Vol. XXXV, Nos. 2 and 3, February and March 1937.

8 millions. The figures for Australia and Canada show a similar slowing down.

In Canada and the United States, at least, the simpler means of extending the area under cultivation—ploughing up natural grassland or burning down forest—have already come near to their limit. North America, like Europe and Asia, has felt the pressure of population too long to leave room for any easy extension of agriculture. Elsewhere, in the Argentine and in Brazil, for example, there is still new land to be won—the Argentine Government believes that 238 million acres (one-third of the whole country) is suitable for agriculture and cattle raising, and in Brazil less than 20 million acres out of a possible 28 million have been ploughed up—but the indications are that this new land will give a poorer return for the labour, power and material expended than the land already under cultivation. More people can be supported, but at a lower standard of living. The schemes initiated by the British Government in Tanganyika show the possibilities of Africa just as the slow progress of these schemes has revealed the difficulties.[1] 'New land' which could be cultivated by workers willing to accept a return for their labour no greater than that of the agricultural worker of western Europe, amounts to no more than a small fraction of the area already under cultivation. Any further extension of farming must depend on a widespread acceptance of lower standards, or on irrigation and the reclamation of marsh and desert.

Erosion

The earth's thin covering of soil varies from eight or nine feet to a mere inch or two; the average over the earth's cultivable land is only about seven or eight inches. This frail integument of dust, far more than coal or oil or iron, is the world's capital.

[1] In 1947, 7,500 acres were ready for planting with groundnuts as against the 150,000 acres suggested as the season's programme in the White Paper of February 1947. (The original estimate was 3,210,000 acres to be cleared by 1953. By the end of 1950, 142,000 acres had been cleared, and the estimate for 1953 was 81,450 acres under crops, 50 per cent of which were millet, sorghum and maize.—*J.R.*)

If it were destroyed, or blown into the sea, it would take something between 2,000 and 10,000 years to replace it. So long as the people of Europe and the Mediterranean seaboard lived on the produce of their own land, the European farmer believed that it was his duty to hand over his estate to his son in as good a condition as he received it; and indeed the methods of agriculture at his disposal did not make it easy for him to destroy the fertility of the soil. A kindly climate with gentle and steady rainfall, a soil whose texture helped to resist disintegration, and over vast areas a gentle angle of slope that offered no chance to the incipient gully, all these helped the European farmer, and when new implements, new systems of irrigation, and new crops made it possible to gain a greater yield per man, the farmer could still hand over his land in a condition no worse than that in which he received it. To this day, the soil of Europe is, on the whole, cultivated with prudence and respect; it will support as many people now as it did a century ago.

The discovery of new continents, inhabited only by hunters or by people whose primitive agriculture gave only a trivial yield, opened up new possibilities. Forests could be cleared and turned to grassland, grassland could be ploughed up and planted with corn, yields could be doubled, trebled and quadrupled. A vast expansion of population became possible; and the new populations did not need to live near the land that fed them. They could stay at home and make machines and implements and clothes for the settlers who subdued the African jungle or ploughed up the Canadian prairie. The European farmer could enrich his land by using it as standing-ground for cattle fed on foodstuffs from overseas. Some of the fertility of the newer countries was transferred to the old.

For a time, there seemed to be no limit to the land available. When one forest was cut down, the lumberjack could move on to another, when over-grazing or too intensive cultivation exhausted the fertility of one region, the farmer could trek on. But the destruction of the forests disturbed the balance of rainfall, drainage and evaporation; the ploughing up of the native coat of vegetation laid the soil open to erosion by wind and rain;

over-cropping impoverished the soil and damaged its texture. Wind and rain, fiercer in most of the new countries than in temperate Europe, are forever at work, even on level ground: under grass or forest trees, less than an inch of soil will vanish in five thousand years, and new soil will be formed rather faster than the old is lost; but under corn or cotton, if no care is taken to restore the humus, an inch of soil will disappear in eighteen months to seven years; and on land left bare, an inch will be lost in anything from one year to three.

It was two hundred years ago that Peter Kalm, a New Jersey botanist, noticed that recent storms had washed away several acres of land sown with wheat and rye. At all times cultivation reduces the cohesion and porosity of the soil, and unless proper care is taken, the rainwater sweeps off a thin sheet of soil each year. As less and less absorbent layers are exposed, the rate of erosion increases, but it was not until the beginning of the present century that the menace began to haunt the minds of men. Deep gullies appeared on the bare hillside; dust-storms lifted millions of tons of soil from the great plains; rivers, choked with detritus from the eroded landscapes near the source, flooded the fertile landscape lower down. In the past thirty years, more good soil has been lost than in the whole of previous history. Nearly a million square miles of fertile land have been turned into desert; the French coalminer, the Chinese coolie, and the housewife in Detroit have all had to go short of food because 20 per cent of the world's ploughland has been destroyed and much of the remainder has been damaged.

'Erosion is the biggest problem confronting the country, bigger than any politics.' General Smuts was speaking of South Africa; but the same could be said of Australia, India, Canada and the U.S.A. And indeed the matter has in it the germs of the politics of the future, for if the world begins to yield less food there will be sufferings and upheavals beside which the competition of rival empires and the squabbles of capitalist and factory-hand will appear to be the innocent amusements of children at play.

In the United States, the soil has lost 40 to 50 per cent of its

fertility in the past thirty years;[1] and in addition, vast quantities of soil have been swept away in storm and flood.[2] By 1945, 50 million acres of arable land had been utterly ruined, and only 80 to 100 million acres were reported entirely free from some degree of erosion out of a total of 460 million acres of good arable land. To-day, there are over 200 million gullies eating away the soil of the United States. They range in size from giant canyons to tiny runnels which are only just beginning their career of destruction. In the Great Corn Belt of the Upper Mississippi, which contains half the first-grade land in the U.S.A., between fifteen and thirty inches of topsoil have disappeared; in May 1934 a single storm lifted 300 million tons of Middle Western soil and carried some of it as far as the Atlantic coast.[3] In the Piedmont area, among the foothills of the Appalachian mountains, an area of 20,000 square miles has lost over three-quarters of its topsoil, and most of the remaining 40,000 square miles have suffered in some measure. In the U.S.A. as a whole, soil erosion still spoils 500,000 acres of good land every year; if erosion were to continue at its present rate, the country would lose over three-quarters of its fertile soil by the end of the present century, and only about 55 to 75 million acres would be entirely free from some degree of erosion. In the dry pasture-lands of the Western States, the prospect is scarcely brighter. An area of over a million square miles has lost, through over-grazing, nearly half its capacity within fifty years; and even now, 17 million sheep and cattle are being grazed on land with a sustained grazing capacity of 10 or 11 millions.

Farther north, in Canada, the problem is similar to that of the prairies and Great Plains of the U.S.A. There is some water erosion in British Columbia and on the Peace River tableland, and there is some over-grazing in the ranching areas; but the

[1] The fact that the actual yields have not declined in some areas merely means that better seeds are being used. Crop yields in eastern Canada have remained stationary in spite of greater use of commercial fertilizers and better farm machinery.

[2] The U.S.A. loses annually 3 million tons of soil through erosion, and 2½ million tons of phosphates in harvesting and grazing.

A. E. Burges, *Soil Erosion Control*. Atlanta, Georgia, 1936.

main problem is that of wind-erosion in Alberta, Saskatchewan and Manitoba, where great dust-storms sweep away the soil from large areas every spring. Difficult and drastic measures can limit the damage, but nothing can restore the greater part of the area that has been lost.

The problem is acute in the mountainous highlands of Bolivia, Ecuador and Peru, where the Indian peasant, driven out of the lowlands, has been forced to cultivate land that slopes too steeply to resist erosion. In the wheatlands of Chile, erosion is already serious; on the pampas of the Argentine, over-grazing and the ploughing up of grassland have caused wind-erosion comparable with that of the Oklahoma Dustbowl. The wheatlands of Chile, the pasturelands of Uruguay, the coffee plantations of Columbia and Brazil, none of these are exempt, and often, as in Mexico and the Andes, one factor is the cramping of the prolific Indian population on insufficient and unsuitable land.

Similar indirect effects of the coming of the white man are found all over Africa. The limitation of slave-trading and of tribal wars has resulted in a great increase not only in the native population but also in the cattle on which the natives live. The result has been increased destruction of forests, and over-stocking of the pasturelands. In the countries bordering on the Sahara, the forests have been cut down and the land has degenerated first to savannah, then to poor grassland, and finally to bare earth which cannot hold the rain when it falls and is itself easily swept away. Some authorities believe that in recent times the southern boundary of the Sahara has been advancing at the rate of about a kilometre a year. Increasing desiccation is also reported from the countries to the north of the Sahara: in the Trans-Atlas districts of French Morocco, for example, cultivation is becoming more and more difficult year by year.

In South Africa, where five-sixths of the land is suitable only for pasturage, over-stocking and veldt-burning have destroyed the natural vegetation, with consequent erosion and flooding, to such an extent that until the Drought Investigation Committee issued its report in 1923 it was widely believed that the climate was becoming drier and the rains more torrential. In

other parts of Africa, the cultivation of cash-crops, such as cotton and maize, which are more conducive to erosion than any others, and the cultivation of hill-slopes without proper terracing, have destroyed the age-long balance achieved by the natural vegetation. In Tanganyika, one-tenth of the whole area (and that the most valuable) is threatened. In Uganda, where the area under cotton increased, in the years between 1916 and 1936, from 200 square miles to 2,500 square miles,[1] the problem is more serious. Reafforestation is urgently needed to mitigate the effects of torrential rainfall. In Kenya, the Turkana Desert is said to be spreading at the rate of six or seven miles a year; and in the areas farmed by Europeans much of the soil has already become exhausted through continuous cropping and the neglect of any measures to replace the humus. 'Some areas in Kenya have already reached such a state of devastation that nothing short of the expenditure of enormous and quite impossible sums of money could restore the land for human use above a bare and precarious subsistence standard.'[2]

The great continent of Asia, which feeds more than half the population of the world, suffers from erosion no less than Africa and North America. In recent centuries the expansion of the Asiatic population has kept pace with that of the rest of the world. Better transport and wider areas of government have made it possible to avoid the worst results of local famine; if food was lacking in one area, it could be provided from another. But the result has been that the population of the continent as a whole has risen to that precarious level at which a crop-failure anywhere means short commons everywhere. And the increased intensity of cultivation and of grazing has brought large areas to the threshold of destruction. India presents a particularly difficult problem; the security and stability brought by the British resulted in a huge increase in population. The result was a greatly increased pressure on the land. Over large tracts of country, excessive grazing has destroyed the natural grassland,

[1] It has since gone back to 1,620 square miles.

[2] G. V. Jacks and R. O. Whyte, *The Rape of the Earth*. London, 1939; published in America as *Vanishing Lands*.

and the village cattle depend on the last vestiges of shrub-growth for their daily food, thus year by year exposing the bare soil to wind and flood. 'The amount of erosion caused directly through this state of affairs has to be seen to be believed.'[1] Elsewhere in India, there is some erosion through the cultivation of cash-crops such as tea and coffee; and in Ceylon erosion is widespread largely through the rapid development of tea and rubber planting. The early planters did not understand the value of surface weeds in binding the soil together and protecting it from sun, wind and flood; and although the vicious practice of clean-weeding has now been practically abandoned, the damage has been done.

The increased yield of Asiatic Russia has not all been gained by prudent methods of cultivation (though the worst erosion problems of the U.S.S.R. are in Europe),[2] and in China the rich loess soil of the north-west has been gradually exhausted through long use. Professor J. Thorp[3] has argued that the only hope of saving the soil of this region lies in a change from arable farming to animal husbandry: if the Chinese people cannot adapt themselves to this revolution in their mode of life, then the uplands will gradually become depopulated.

In Australia, the effects of wind-erosion on the over-stocked pastoral districts bordering on the central desert are horrifying;[4]

[1] R. M. Gorrie in *Herbage Reviews*, Vol. V, No. 2, June 1937.

[2] It has been very difficult to get figures illustrating the extent of soil erosion in the U.S.S.R. In a paper written in 1938, G. V. Jacks and R. O. Whyte prefaced their survey of methods of soil conservation in the U.S.S.R. by the remark that 'No detailed survey of eroded land in the Soviet Union has been made, but the available data and reports show that erosion is fairly extensive and increasing, although it has not reached the same catastrophic proportions as in the United States'. Later, they write: 'The Soviet Union, however, has been forewarned by the disasters that have overtaken other countries and it has inherited from the imperial era a scientific tradition in pedology with an exceptionally deep insight into fundamental causes.' Technical Communication No. 36, *Erosion and Soil Conservation*, published by the Imperial Bureau of Soil Science, Harpenden, 1938. —*J.R.*

[3] J. Thorp, *Geography of the Soils of China*. Nanking, 1936.

[4] See F. N. Ratcliffe, *Flying Fox and Drifting Sand*. London, 1938.

in the semi-arid pastures of South Australia, over-stocking has reduced the bush-cover to 10 to 25 per cent of its original density. In a bad season—and a really smashing drought occurs at least once every ten years—the sheep eat the shrubs down to the roots, and the land becomes a desert. The recuperative power of this waste is amazing: a week's rain, and the land is rich with grass and flowers and the salt-bush springs to life again. But this renewed life springs from seeds long hidden in the ground and from roots already well established. What will happen if the sheep and rabbits do not let the new growth seed? Even the salt-bush has its natural term of life; and if no new shrubs are allowed to grow to maturity, sooner or later the salt-bush cover will vanish and the land will be exposed to the devastation of sun and wind. But although wind-erosion is spectacular, water-erosion is even more serious, especially in the undulating wheatlands of New South Wales, where the average angle of slope is too great for ploughed soil to withstand the effects of sudden storms. In Queensland, as elsewhere, the cultivation of cotton has led to erosion by water. In Tasmania, sheet-erosion is common in the north, and there is also severe water-erosion in the apple-growing districts of the south.

It is difficult to assess the total damage throughout the world; but it is quite clear that in less than a hundred years the white man has destroyed at least a fifth of the world's fertile land, either by his own handiwork, or by driving native peoples to cultivate unsuitable land, or by allowing them and their flocks and herds to multiply beyond the grazing capacity of the land. The evidence is clearest and most damning in the case of the United States only because that country has been the first to treat the problem seriously. The work of the T.V.A. over an area of 40,000 square miles, and of the Bureau of Reclamation with its 65,000 square miles of arid and semi-arid land, is sufficient guarantee that the people of the United States will attack the problem with patience, energy and vision; but the price of success over the country as a whole is a deliberate *reduction* of yield in some areas. The landscape must be given the type of vegetation which offers adequate protection against flood,

drought and wind, not that which yields the biggest quick return in cash. The store of inorganic matter and mineral salts in the soil must be replenished year by year, not drawn upon as if it were inexhaustible. Whether India and China will tackle the problems of erosion and reclamation with the same vigour is doubtful, and in many parts of the world the difficulty is not merely a technical one, but a problem of law and custom. As long as people think of the land as a source of quick profit, and as long as they have a system of land-tenure which offers the tenant no return for good husbandry, the world's basic capital will continue to flow into the sea. Europe alone remains a stable element in this picture of human fecklessness. At present, the rate of loss in the world in general is at least 20,000 square miles a year, and is still increasing. If other countries make an effort comparable to that of the United States, the rate may be stabilized within ten years and then reduced. If that can be done, the additional loss in the next fifty years need not exceed the million square miles or so lost since 1890, and little by little some of the ruined land can be reclaimed.

Land Reclamation

In principle, there is not a single acre of the world's surface which could not be made to yield some kind of crop if we were prepared to take sufficient trouble. Vast turbines and pumping stations, endless conveyor belts carrying soil up precipitous slopes, enormous windshields dwarfing the Great Wall of China, could bring fertility to the sand of the Gobi or the arid slopes of Mount Sinai. But all this is fantasy: we are concerned not with what is *possible*, but with what is *economically possible*. It may be technically possible to pump the Mediterranean dry or to cultivate the soil within the Antarctic Circle, but it is obviously silly to cultivate tomatoes in Greenland if it requires the equivalent of ten men's labour to maintain a hothouse that supplies a dozen tomatoes in a year. To be practical, a scheme should give us a fair return for our efforts within twenty or thirty years.

In Europe, only here and there do we find marshes to drain

or land to be reclaimed from the sea, and these form only a tiny fraction of the whole. The combined area of the land reclaimed in Holland and Italy in the past twenty-five years is only 287,500 acres, and there are no other schemes of this kind in sight.

There are certainly great areas in the U.S.A. which at present yield no crops. West of the 100th Meridian, there is a vast area of 760 million acres, the greater part of which is arid desert. Already 20 million acres have been irrigated, and it is estimated that another 10 million acres are capable of irrigation; but for the rest of the desert there is no water available: the local streams are relatively small and are overtaxed already, and the nearest great rivers are thousands of miles away. There are some tasks so stupendous in relation to the reward offered that even the enterprising spirit of America quails.

Furthermore, water that is used in one way cannot be used in another. The Central Valley of California, near San Francisco Bay, is an area reclaimed from the sea; but the sea is recovering its own, for the San Joaquin and the Sacramento have been so drained by pumping into irrigation ditches that they no longer have the force to hold back the ocean tides.[1]

Very little of the vast desert area of Australia can ever be made fertile by irrigation. The whole country suffers from recurrent droughts, and at all times suffers from acute water-shortage. Over an area of more than a million square miles there are no rivers at all, in another million square miles the rivers flow only when there is a rainy season, and sometimes they are absent for years at a stretch. True, the great rivers of the south-west are available for irrigation, but there irrigation is in fact already highly developed. Much of the inland grazing territory depends on artesian wells; but the water from these wells does not appear to be inexhaustible, and in the Great Artesian Basin, which covers 600,000 square miles (mainly in Queensland) the flow from all the wells is diminishing—in some wells it has fallen by 50 per cent in ten years and is still diminishing. Not until man can economically produce rain from clouds

[1] K. Glover, *America Begins Again*. New York, 1939.

over large areas will the greater part of Australia become habitable.[1]

The desert regions of Asia certainly offer some prospect of addition to the world's total of cultivated land. There are the areas which were once cultivated and then allowed to relapse to desert, and there are the still wider areas which have never been irrigated at all. Iraq, for example, could with further extensive irrigation support a population several times greater than at present—perhaps 5 million more. During the British occupation in 1914–18 very considerable works were carried out (in 1919 the area under cultivation was 1,547,000 acres—an increase of 64 per cent on the previous year) and between 1921 and 1948 new irrigation has added another 1,729,000 acres. It must be remembered, however, that on many of Asia's greater rivers, irrigation schemes have already been put into operation in the areas where they are most easily carried out. Any extension will become increasingly difficult, and it can be accomplished only by vast capital expenditure: that is to say by deliberately sacrificing the present consumption for the sake of a future increase.

The Yield per Acre

The rate at which the earth's soil is already being washed away makes one cautious about predicting any great increase in the yield of food per acre; but the difference between the yields in different countries is so great that one is tempted to believe that some considerable improvement is possible in the countries which at present show the poorest returns. Canada, Australia, Argentina, the U.S.A. and the U.S.S.R., for example, harvest only from 11 to 17 bushels of wheat per acre. In France, Italy and Hungary the average yield per acre is about 22 bushels; in Britain, Germany, Sweden and New Zealand, it is about 33. The worst harvest Britain has known for forty years

[1] Some interesting experiments were carried out in 1947, based on Bergeron's theory that rain falls only from clouds that contain both water drops and ice crystals. Four hundred pounds of solid carbon dioxide were shot into a 'super-cooled' cloud above the normal freezing level. Rain fell over an area of 20 square miles. (The process was used during the New York water shortage in the summers of 1949 and 1950.—*J.R.*)

was nevertheless better than the best the United States has ever had.

For centuries before 1840, the yield in Europe was from 10 to 12 bushels per acre. The development of new strains and the use of 'artificial' fertilizers brought about a great increase, and since the beginning of the present century, the yield of wheat has been remarkably steady. In these 'old' countries, the soil is well cared-for, the varieties sown are adapted to the soil and climate, and unless the wheatfields are overstrained (as they were overstrained in Britain during the war of 1939–45) there is no reason to expect any deterioration. Nor is there any reason to expect any appreciable improvement.

In most of the newer countries, the position is far less clear. One would think that there was ample room for improvements; though the low average rainfall in many areas must always be a handicap. In Australia and the Argentine, there has indeed been a perceptible improvement in the average yield.[1] In the United States there has been no marked change in the last forty years.[2] In Canada, far from improving, the yield declined from about 19 bushels per acre in the early years of the century to about 15 bushels per acre in the forties.

In Australia, where the rainfall is inadequate and uncertain —at the best, it is less than a third of that of Great Britain— wheat-farming is a hazardous business, and the yield fluctuates wildly from one season to another. In 1901–2, for example, it was 2·4 bushels per acre; the following year, it was 13·3. The 1938–9 season yielded 15·8 bushels per acre; the following season gave only 6·5. Considering ten- or fifteen-year periods, however, we can detect some order in the erratic figures: the yield per acre declined steadily from an average of 12·8 bushels in the sixties to 7·3 bushels in the nineties, partly because less suitable land was being brought into cultivation. Thereafter, however, although the area of the wheatfields continued to increase,

[1] See Appendix B, Table VII: Yield of Wheat.

[2] The improvement during the years 1946–8, when the average yield rose to 17·8 bushels per acre, was not maintained in 1949, when it reverted to 14·9.—*J.R.*

the use of improved varieties raised the yield until in the twenties it again reached a level of 12 bushels per acre, around which it has fluctuated for a quarter of a century: the gain from the use of improved varieties has been just enough to counterbalance the decline due to the cultivation of poorer land and the gradual exhaustion of the existing wheatfields. The Australian farmer is courageous and hardworking, and he has been well served by plant-breeders such as Farrer, but his battle is none the less difficult and one can scarcely expect any appreciable further improvement in the yield.

In Argentina, however, where much of the farming is still rather primitive, there is still room for improvement in the strains sown; but in Canada and the U.S.A. every effort has been made to find the best varieties; and in many cases the varieties sown to-day would give under similar conditions a yield twice as great as that given by the varieties sown forty years ago. The conditions are not, however, similar: the land has deteriorated, as one would expect when nearly half-a-ton of wheat per acre is removed year after year without any replacement of the humus and mineral salts. On the older land, the yield is declining; and much of the newer land is not as good as that which was at first selected for cultivation. On the whole, one must expect a gradual decline in fertility in these countries until the farmers learn to give back to the soil as much as they take from it. The use of 'heavier' varieties will maintain, or even increase, the yield for a time, but will hasten the exhaustion of the soil. The radical answer is farming on the European model, with full rotation of crops and a proper ratio of pasture to arable land. The revolution accomplished in Denmark, where a whole country deliberately set itself to turn over from the intensive cultivation of cereals to a mixture of agriculture and dairy farming in order to save the soil, will have to be repeated—though perhaps less drastically—elsewhere.

If that is done, the yield per acre in Canada and the United States might be raised to the level prevailing in France: but the change will not necessarily mean an increase in the total crop, for much of the land each year will be 'resting' from wheat-

growing; and it will certainly mean a rise in the man-power (or at any rate the horse-power) required per ton. If the necessary horse-power and fertilizer are forthcoming, and if in other respects we take more care of the soil than we have done in the past, we might expect some increase in the total yield from the areas already under cultivation; but our expectations ought to be modest and we should remember that they are based on a new respect for the soil and on an increase in the amount of labour and material we are willing to expend in order to gain a ton of wheat.

In the hill-lands of India, and in many parts of Africa, the first steps towards checking erosion must be a reduction in the number of animals grazed. Elsewhere, the great need is for a rotation of crops or for a period of fallowing between crops. In other regions, notably the United States, the soil can be saved only by restoring part of the cultivated area to forest. The prospect of increasing the yield per acre without immediately damaging the soil does not seem bright, except perhaps in parts of South America, where there is still scope for improved methods and better varieties of seed. In semi-arid areas, such as the wheatfields of South Australia, it is worse than useless to attempt to grow high-yielding crops for which there is not enough water; the use of artificial fertilizers or of high-yielding seeds merely makes the water-shortage more acute.

On healthy soil, provided the rainfall is adequate, it is always possible to obtain an increased yield for a year or two by the use of liberal doses of artificial fertilizer—as was done in the British Isles between 1939 and 1945. But the health of the soil depends not only on its inorganic constituents, but also on the humus which binds the soil together, helps it to hold moisture, and harbours the countless bacteria which play their part in the development of the plant. The organic humus consumed in the course of the plant's growth is not replaced, the quality of the crop deteriorates, plant diseases appear, and the soil itself loses its cohesion and is swept away by wind and water or cakes hard on the surface so that water runs off without reaching the roots of the thirsting plant. When yields have been boosted above a

certain point—which appears to be the level of cropping reached by ordinary good farming—the ultimate result is a greatly reduced yield.

Whether artificial fertilizers are *always* harmful is a disputed point: the word 'artificial' provides a troublesome red herring which sometimes confuses the judgment of intelligent people who feel strongly that nothing is good unless it is 'natural'. All naturally fertile land owes its fertility to the slow natural processes which break down the native rock and distribute its valuable lime and nitrogen and phosphates over the plains; the supply of 'artificial' fertilizers is merely an acceleration of this process; and it probably becomes harmful only when it disturbs the balance between mere sand, clay and mineral salts on the one hand, and organic matter on the other. What is clear is that one cannot indefinitely go on removing large quantities of, say, potato or beetroot from an area and replacing the stolen organic matter by nothing but mineral salts. With careful husbandry, the average yield per acre in Europe, North America and Australia can probably be maintained. In the agricultural and pastoral districts of India, China and Africa, it may have to be reduced voluntarily if we are to forestall a catastrophic natural reduction. In South America, and in some parts of Central Africa, there is probably scope for increasing yields. Detailed arithmetic is impossible, but taking the world as a whole one cannot foresee any large permanent increase in the yield per acre.

Fertilizers

The inorganic substances essential to the growth of plants include lime, potash, nitrogen (in the form of nitrates or ammonia) and phosphates: if broken rock happens to contain these constituents (and minute quantities of others) and is not too acid, plants will begin to grow in it, and in due course the humus formed by their decay will enrich the sand or gravel and convert it into soil suitable for the growth of crops. If the crops are removed and the lime, potash, nitrogen and phosphates which they contain is not replaced, the land becomes impoverished

and the yield decreases year by year until the soil ceases to be worth cultivating.

Lime is easy enough to replace: it exists in enormous quantities all over the earth in the form of chalk and limestone deposits made up of the fossil remains of marine organisms which accumulated in the millions of years when the present land-surface was at the bottom of the sea. It needs little or no preparation, and simply has to be scattered over the fields; there it crumbles and is worked into the soil, where it not only serves as a plant-food but also counteracts any acidity in the soil. Indeed, lime is more often used to counteract acidity than to supply any deficiency of calcium. There is no danger whatever of the world running short of lime.

Nitrogen at one time presented a more serious problem: the majority of plants need a great deal of it, and although the earth's atmosphere contains more than three thousand million million tons of nitrogen, very few plants can make use of it in this form. In order to be useful to wheat or oats or trees it has to be chemically combined as a nitrate or an ammonium compound, and at one time there appeared to be a serious danger that the continued heavy cropping of the world's wheatlands would so impoverish the soil that crops would begin to fail. Nearly fifty years ago, Sir William Crookes said that unless some practical method of 'fixing' atmospheric nitrogen could be found, the world's population would be reduced to starvation in a few decades. The invention of the cyanamide and other fixation processes has solved that particular problem. Three million tons of nitrogen are 'fixed' and returned to the soil as fertilizers every year. Another half-million is derived from the by-products of coal distillation, and over a quarter of a million tons is obtained in the form of Chile saltpetre from the great deposits in Chile. Up to 1939, Germany produced 22 per cent of the synthetic product, the U.S.A. produced 14 per cent and France, Britain and Japan about 8 per cent each.[1]

[1] A. M. Bateman, *Economic Mineral Deposits*. New York, 1942. (In 1949–50 the percentages were U.S.A. 27, Germany 11, French Empire and Saar 5, U.K. (including Colonies), Japan and Chile 7 each.—*J.R.*)

The provision of potash is relatively simple. Until the discovery of the enormous deposits at Strassfurt, in Germany, wood ashes provided the only known source; but to-day the world uses three million tons of potash (K_2O equivalent) every year. Before 1939, three-quarters of the world's supply came from Germany, which has deposits (estimated at 3,000 million tons) sufficient to last 200 years at the present rate of extraction. Other deposits are found in France (estimated at 1,500 million tons), Spain (2,000 million tons), Russia (15,000 million tons) and the U.S.A. There is plainly no danger of any shortage.[1]

Phosphates—the lack of which was acutely felt by many European countries during the war—are found in the U.S.A., where the known reserves amount to 9,000 million tons, in the U.S.S.R. and in French North Africa, which has known reserves of 1,500 million tons and possible reserves of 10,000 million tons. As the world's annual consumption is only 16 million tons, the known deposits will last for quite as long as one cares to look ahead.

The Organic Constituents of Soil

The minor inorganic elements needed in fertile soil exist in ample quantities widely distributed over the earth's surface, so that so far as inorganic matter is concerned no difficulty is likely to arise unless commerce is again interrupted by a major war. The organic constituents, however, present a very difficult problem indeed.

The loss of humus through cropping can be partly made up by ploughing in the roots and stubble, which contain organic matter derived from the carbon dioxide in the air; but continuous cropping with wheat or oats does *not* provide any adequate replacement. The distribution of farmyard manure is a solution in countries where cattle are fed on imported food; but taking the world as a whole this merely shifts the problem from one area

[1] (In an address to the Newcastle section of the Society of Chemical Industry on 17th October 1950, Dr. Alexander Flek stated that recent investigations in Yorkshire had revealed a potash-bearing area with an estimated minimum content of 200 million tons, which if developed would be enough to supply British requirements for at least 140 years.—*J.R.*

to another. The only general solution is the alternation of crops, growing in successive years crops which make varying demands on the soil and at intervals growing some crops such as clover or lucerne which is then ploughed in. With a suitable cycle of crops the health of the soil can then be maintained indefinitely, and the yield from each sowing of a given crop can be maintained or even improved; but obviously if wheat is grown only two seasons out of four, the average annual yield of wheat is reduced. It is this reduction which we must be prepared to face when farmers in the 'new' countries begin to nurse their soil as carefully as do their opposite numbers in Europe.

CHAPTER III

THE WORLD'S FORESTS

'The woods decay'

The silence of a northern pinewood under snow or the dappled sunlight of a temperate forest of oak and chestnut is part of man's heritage of happiness and beauty. Even the rich luxuriance of the tropical jungle has its moments of overpowering beauty as well as its moments of terror. Here, as on the high seas, is a world without man, the world 'of woods decaying, never to be decayed' with which man has to live in harmony if he is to find harmony at all. A great forest, no less than a wide prospect of ripening cornfields, can be a source of strength and courage as well as a storehouse of natural wealth. But the material wealth is vital to human life as we know it: every man, woman and child in the world to-day needs the produce of at least an acre and a half of forest, and the industrialized societies of Europe and America use far more. Timber is the raw material of paper and innumerable synthetic products, as well as a building material and a fuel; and even if timber were useless, forests would still be necessary to regulate the flow of water from the hills and trees would still be needed to check erosion and to shield the crops from wind. Where the ancient groves and forests have vanished, as over large areas of the Middle East, the land reverts to desert; and in the United States the reckless destruction of the forests has been one of the main causes of soil erosion.

The World's Resources

At the present time, rather more than a quarter of the earth's land area is covered with timber; there are three and a half

million square miles of forest in the U.S.S.R., more than one and a half million in Brazil, more than a million in Canada, and about 975,000 square miles in the U.S.A. Argentina has 335,000 square miles, and Peru has nearly as much; India, China, Rhodesia and the Belgian Congo each have about 300,000 square miles and Nigeria and New Guinea have only a little less. The world's total of forest or jungle is about fifteen and a half million square miles.

It would seem at first sight that here were ample supplies of timber for any foreseeable future: after all, the world's loss of forest each year, by cutting and destruction, amounts to far less than 1 per cent of the total. But the matter is really a little more difficult. The figures we have given include a great deal of poor scrubby forest useless for lumbering. Furthermore, some of the great forest areas of the world are inaccessible by road, rail or river: the Dominion Forestry Service regards half of the Canadian forests as 'commercially inaccessible', and in Russia, where rather more than a third of the forests are in swamps or marshes, and others are a thousand miles from any practicable transport, the proportion is even greater. Again, many of the great tropical forests are made up of mixed stands where every separate tree would have to be selected, felled and hauled on its own. It must be remembered that it is not just wood that is wanted, but particular kinds of wood; the most urgent demand is for the softwood which can be cut by mass lumbering, and for this purpose suitable forests to supplement the resources of Europe are to be found only in Canada, Russia and the United States.

Indeed, of the total fifteen and a half million square miles of timber, only ten million is considered capable of production, and of that ten million only five and a half is considered accessible at present. All current production comes from this area. The *available* forest area of Russia is about one and a quarter million square miles, and the available area in Canada is only half a million. Vast though their forests are, it is not beyond human power to destroy them within a generation; and the history of the lumber industry in the U.S.A. gives us reason to fear that this is only too likely to happen.

The Forests of North America

Before the coming of the white man, nearly half of the three million square miles of the United States was covered with forest; to-day, only one-tenth of that virgin forest remains. The total area of forest, good or bad, natural and planted, has been reduced to little more than half the original area and contains only a third of the original quantity of saw-timber.

In some parts of the country the devastation is appalling. In 1830, the State of Michigan was one vast forest; within a century, only 8 per cent of the original stand of 380 billion feet remained.[1] In Michigan, Wisconsin and Minnesota, more than 30,000 square miles of former forest have been abandoned by its owners because they do not think it worth their while to pay the taxes; and with the disappearance of the forest, the farms too have decayed. In 1890, the townships of Arc Sable and Oscoda had 8,346 inhabitants; by 1920 the population had dwindled to 942. In thirty-seven counties of southern Michigan, there are less people to-day than there were in 1880. The lumberjack has moved on. To-day, he is in Georgia, Alabama and Louisiana, using tractors, mechanized saws and overhead conveyors to provide three and a half million cubic feet of pulpwood in America every day of the year. And the history of Michigan is being repeated: twenty years ago, Fullerton, Louisiana, was a thriving town of 5,000 people. By 1939, all that was left of the town with its schools and hospital and swimming pool was one old Negro living in the vault of the abandoned bank. Every single issue of a New York Sunday paper costs twenty acres of timber: no one has yet discovered a process for turning newsprint into trees.[2]

Over the whole country, the original stand of timber was about 5,200 billion board feet; by 1924, only 2,400 billion feet remained. In the nineteen-twenties the average cut for lum-

[1] K. Glover, *America Begins Again*. New York, 1939.

[2] On Sunday, 4th June 1950, the *Kansas City Star* appeared with 252 pages, commemorating the city's hundredth anniversary. A single copy weighed 3¾ lb., and the issue used up 773 tons of newsprint.—*J.R.*

ber, pulp, fuel, etc., was over 50 billion; another 5 or 10 billion board feet were lost in forest fires or destroyed by drought, pest or storm, and the annual excess of consumption and destruction over new growth was nearly 30 billion. The slump after 1930 gave the forests a brief respite, but the annual loss still exceeds the new growth, and in the nineteen-forties, the annual cut again rose to the level of the twenties.[1]

If the rate of loss of softwoods were to continue, the last tree in the commercial softwood forests of the U.S.A. would be cut down within our grandchildren's lifetime.

The people of America are aware of the problem. 'Each year more good saw-timber becomes ripe for the cutting, but we cut almost twice as much as becomes ready,' says one American writer.[2] 'We have removed the forests as we would coal from a mine, with little thought of a new crop.'[3] As long ago as 1891, forest reserves were established; to-day the Department of Agriculture controls an area bigger than France; but this is only a quarter of the forest area of the whole United States, and it is the remaining three-quarters that produces nine-tenths of the saleable timber, and of this privately owned land less than 5 per cent is systematically replanted and a vast area is annually destroyed by fire. Throughout the twenties and early thirties, forest fires damaged 40 million acres a year, and although this figure was reduced in the next ten years, the U.S.A. still loses by fire a forest area around 20 million acres every year. With a total annual loss, in saw-timber sizes, of 50 billion board feet against an annual growth of 35 billion, the time is obviously approaching when the U.S.A.—which at present consumes nearly half the lumber cut in the whole world and more than half the paper—must either restrict its consumption or turn to the forests of Canada for supplies.

This is, indeed, what has already happened: about four-fifths of the newsprint consumed in the U.S.A. is either manufactured

[1] See Appendix B, Table VIII: U.S.A. Timber.

[2] W. R. van Dersal, *The American Land*. London and New York, 1943.

[3] G. J. Miller and A. E. Parkins, *The Geography of North America*. New York, 1934.

in Canada or made from Canadian wood-pulp. Canada exports more paper and wood-pulp than all other countries combined. Between 1939 and 1948 Canadian exports of newsprint rose from three million tons to between four and five million tons, exceeding in value a year's shipments of wheat and flour. How long can this great drain on the Canadian forests continue? The Royal Commission on Pulpwood in 1924 estimated that supplies would be exhausted in sixty-three years. Professor Brady, writing in 1932, said: 'At the present time the forest is exploited like a mine. . . . While conservation of natural resources has champions who pay lip-service in after-dinner addresses, the community has still the colonial belief in inexhaustible abundance.'[1] It is only fair to say that the Dominion Government is quite as deeply concerned as any government can be: but up to the present the gain through conservation measures has been trivial in comparison with the extension of the lumber industry itself.

With careful forest management, Canada could permanently supply about 32 billion board feet of lumber a year; the United States could supply a little more. But it is very doubtful whether forest management will become sufficiently extensive to save the forests of Canada and the U.S.A. from further depletion; and even if it did, the combined figure is only about 25 per cent above the present rate of consumption of the two countries, and consumption is still increasing. It is fairly obvious that within thirty years (allowing for a moderate increase in population) the people of North America will either have to restrict their consumption or look even further afield for supplies of timber and wood-pulp. It is still more obvious that Britain will have to look elsewhere unless she can outbid the Canadians and Americans in their own markets.

The Resources of Other Countries

The forests of Norway, Sweden, Finland, Germany, Switzerland and France already go far towards meeting Europe's needs, which are more modest than those of the U.S.A., but in the long

[1] A. Brady, *Canada*. London, 1932.

run Europe will need softwood from Russia. If the people of Europe and the U.S.S.R. consumed timber as fast as the citizens of the U.S.A., the Russian forests would be wiped out in less than thirty years, no matter how carefully the Russians replanted.

There are, of course, large areas of softwood in other parts of the world, but they are negligible in comparison with those of the U.S.A., Canada and the U.S.S.R. For the most part, the tropical forests do not produce timber suitable for pulping; and the hardwood trees, from the nature of their growth, are expensive to fell. The terrain, too, is often difficult; and the menace to the tropical forest is therefore not the lumberjack but the farmer, whether European or native, who burns down whole areas to provide ploughland or pasture.

Where hardwood forests are readily accessible, their history has often been the same as that of the pinewoods of North America. In Australia, for example, with a relatively small forest area, the forests of New South Wales have been reduced to a third of their original extent; the red-cedar region of northern Queensland has been stripped of its valuable timber; and the jarrah and karri forests in Western Australia have been unscientifically thinned out without any attempt at economy or reafforestation. Since 1914, however, there have been great advances in forest management throughout the Dominion. The total area under timber and 'possible for permanent reservation' is estimated at 20 million acres, which ought to supply enough timber for 20 million people; in practice, however, Australia is already a timber-importing country, and the value of the softwood imported is double that of the exports of the hardwood.

There are still vast reserves of timber in the forests of Africa, South America and India, but not all of them have easy access to the world's markets; and suitable softwood for pulp is likely to become increasingly scarce even if measures are taken to conserve the supply in Russia, Canada and the United States as they have long been taken in northern and western Europe.

Forest Conservation

The problem is not merely to plant seedlings wherever timber

has been felled: young trees need good soil, sunlight and protection from wind. The ideal is a mixture of conifers and deciduous trees at every stage of growth: such a forest rejuvenates itself if the cutting is selective and is restricted to the quantity that can be replaced by new growth within a few years. But the demand for pulpwood cannot be met economically except by mass lumbering, preferably carried out in a plantation where the trees are all of the same age. If the deciduous forests of the temperate zones are not to be exhausted after one or two replantings, there must be some accommodation between the demands of immediate economy and those of good husbandry. At least we could plant belts of beech and ash amidst our monoculture of pine or spruce, and we could limit the area of a given season's cutting to a size that was big enough to be worth working yet small enough to gain some protection from the surrounding areas left untouched. Selective felling of individual trees is too expensive except for high quality timber, but even if we cannot provide the rich undergrowth of a healthy mixed forest, we can at any rate arrange for some rotation of seeding, and provide the seedlings with shade-givers and nurse-trees to bring them to maturity.

In future, we shall have to grow trees as we grow wheat or cabbages, with a careful eye to replacement and the conservation of the soil. The cost, in terms of man-power and horse-power, will rise; and that increased cost will itself act as a check on consumption. The people of North America have 7·4 acres of productive forest per head though only 4·8 acres are accessible, and if they were not living on their capital, they would find it barely sufficient for their needs. The rest of the world has only 2·5 acres of forest per head (1·3 of which are accessible) and can therefore never, in any circumstances, aspire to much more than half the present American consumption of paper and timber. If that limit is exceeded, or if the world's population greatly increases, or if the Americans begin to use their dollars to buy timber from other continents, the remaining forests of the world will go the way of Michigan and Wisconsin.

CHAPTER IV

SOURCES OF ENERGY

Living on Capital

Up to three hundred years ago, mankind lived within its income. Men hunted, tilled the fields and cut down trees, but on the whole they left the earth no poorer than they found it. The amount of stone that was quarried and of clay that was turned into brick amounted only to a negligible fraction of the world's resources; but the invention of the steam-engine, and later of the dynamo and the petrol-engine, altered the whole picture: modern civilization is based on the consumption of irreplaceable capital resources, not for capital reconstruction, as in building, but for day to day consumption. Copper and iron, aluminium and nickel, occur in such large quantities in the earth's crust that there is no danger of any shortage of supplies; but the sources of mechanical and electrical energy are more restricted.

WORLD SOURCES OF ENERGY[1]
(Percentage of total British Thermal Units)

	From Coal	From Oil	From Natural Gas	From Water Power
1913	89·8	5·6	1·8	2·8
1919	84·3	8·9	2·5	4·3
1938	65·8	20·9	4·9	8·4
1947	59·8	23·7	6·7	9·8

[1] *Petroleum Times*, June 1948.

PETROLEUM

The world has enough oil to last for twenty-two years, enough coal to last five hundred, and enough damsilliness to last for ever. The development of the petroleum industry, with the virtual exhaustion of the world's supply practically within a single lifetime, is likely to become one of the curiosities of history.

Petroleum

It has been estimated that the world's proved reserves of petroleum amount to rather less than 80,000 million barrels.[1] In the near future, production will probably average about 3,500 million barrels a year, so that the reserves at present known will probably be exhausted in about twenty-two years.[2]

The geological conditions in which petroleum may be found are well known. Roughly speaking, petroleum is formed when organic matter decays in contact with moisture: the process takes millions of years, and the petroleum becomes available only if layers of impermeable rock prevent it from escaping from the sandstone in which it is stored. These complex conditions have occurred at only a few spots on the earth's surface; and although new oilfields of some magnitude may be discovered it is unlikely that prospectors have overlooked deposits comparable in size with those which have already been tapped.

In general, the conditions of temperature and pressure make it extremely unlikely that petroleum will be found to exist at depths greater than 20,000 feet; drilling has been carried out in the United States to a depth of 17,000 feet; and there the known reserves are already being used up faster than new reserves are being discovered. The discovery of new oilfields, the elimination of waste in production, the increasing use of shale-oil, and the exploitation of oilfields under the shallow seas, will all help to postpone the date when the world's supplies will come to an

[1] Dr. Kirtley F. Mather, 'Petroleum Today and Tomorrow' in *The Advancement of Science*, Vol. IV, No. 16, January 1948.

[2] See Appendix B, Table IX: Known Reserves of Petroleum.

end; but even the most sanguine estimates do not suggest that the world's supplies will last much beyond the end of the present century.

Since 1859, when the first oil-well was drilled in the United States, the world has produced more than 60,000 million barrels of petroleum. Over 30,000 million barrels have come from the United States alone, and as early as 1934 it was estimated that the country had already used half of its known resources. Even if we assume that intensive search will reveal double the reserves known at present, it is clear that if the present rate of extraction were maintained, the oilfields of the United States would be exhausted by 1980; the Russian and Venezuelan reserves would last nearly forty years, and the reserves of the Middle East at least a century. Already, thousands of individual wells become exhausted every year; and the graph of oil-production in Mexico,[1] with its sharp maximum and rapid decline, seems likely to be typical of the history of every oilfield in the world.

In one respect, the curve of production in other countries may be even more striking;[2] in Mexico labour troubles, and disputes and difficulties arising from expropriation, when most of the foreign technicians were withdrawn, caused production to decline before the wells really began to run dry. Had there been no difficulties of this kind, production might have been maintained near the maximum rather longer and would then have declined even more steeply.

The United States, which has only one-third of the world's known reserves, is producing three-fifths of the world's output; and the domestic consumption is still increasing: between 1941 and 1946 it rose from 367 gallons per head to 648, and the domestic demand shows no sign of contraction. The United States, with its huge but scattered population, has nearly three-quarters of the world's motor vehicles; it needs petrol and petrol-driven vehicles more than any other country in the world except possibly the U.S.S.R., and any shortage would have the most

[1] See Appendix B, Table X: Annual Production of Oil in Mexico.
[2] See Appendix B, Table XI: Crude Petroleum Production.

profound effects on the organization of the whole country.[1] The astonishing thing is that till recently the U.S.A., though well aware of the coming shortage, continued to export increasing quantities of petroleum, both crude and refined: from 1926 to 1935 the average annual exports amounted to 47·5 million barrels, and from 1936 to 1944 the average was 89 million barrels. But this could not continue: after a long period as one of the world's leading exporters of petrol, the United States became a net importer of oil to a small extent in 1948. The entry of this wealthy and eager buyer into the world's markets may well raise prices and stimulate production throughout the world. Whether the U.S.S.R., with its comparatively meagre resources and immense and increasing needs, will again become a seller is doubtful. Rumania, Mexico and the Netherlands East Indies can only supply a small fraction of the world's needs; the only major oilfields available are those of the Middle East, where output after a sharp setback in 1940, has rapidly increased.[2] Political disturbances may interrupt the development of these resources; but the known reserve of 32,000 million barrels is appreciably greater than that of the United States, where surveys have been more exhaustive and drillings have been carried to a greater depth.

Three things emerge from the figures we have considered. The first is that in the near future America may well have to buy petroleum abroad or begin to make synthetic oil at home.[3] The second is that so long as the supplies of Iraq and Persia last, those countries and the powers exploiting their oilfields, will enjoy a strong position in the commercial world. Lastly, within twenty or thirty years—failing the discovery of important new oilfields—the whole world will either have to supplement its

[1] The annual peace-time consumption per head in Britain is 90 gallons, in the Soviet Union 50 gallons; and for the world as a whole it is 50 gallons. If everybody in the world consumed petrol as fast as the citizens of the United States, the world's reserves would be used up in less than two years.

[2] See Appendix B, Table XII: Middle East Production of Oil.

[3] The U.S. net imports of petroleum and petroleum products (in million barrels) were 53·4 in 1948; 114·6 in 1949; 203 in 1950. The estimate for 1951 is 254.—*J.R.*

supplies of natural oil with synthetic oil (which is at present more expensive than natural oil) or else reduce its consumption of petrol very drastically.

So long as they can retain their virtual monopoly of the production of Middle East oil, Britain and the U.S.A. are at an advantage over most other powers. Russia, too, though her supplies are likely to give out before those of Persia and Iraq, will also be in a strong position for some years. In the long run, however, if the world wishes to retain the internal combustion engine, it may well be necessary to fall back on coal as the prime source of power, and to face a corresponding increase in costs.

Coal

In 1865 W. S. Jevons, in a book called *The Coal Question*, estimated that British coal resources would be exhausted by 1970. This alarming statement led to the appointment of a Royal Commission which produced the comforting report that, in seams not less than one foot thick, 146,480 million tons were available—enough to last nearly 600 years at a rate of 250 million tons a year if it could all be extracted. More recent estimates have on the whole confirmed this figure, though the figures vary according as one takes one foot or two feet as the minimum workable seam, and according as 4,000 feet or 6,000 feet is taken as the maximum depth of a pit. A sound, conservative figure for good black coal within 4,000 feet of the earth's surface is somewhere about 170,000 million tons. Perhaps only half of this can be extracted, but even so, if it were consumed at the rate of 250 million tons a year, it would last more than 300 years. The period is long enough to be regarded with equanimity: our children's children, and their grandchildren, need not be cold for lack of coal.

For the world as a whole, it has been calculated that the reserves available within 4,000 feet of the surface in seams not less than one foot thick amount to something between 5,000,000 and 7,000,000 million tons.[1] Estimates of the resources of the

[1] The figure given as a result of the investigations of the Twelfth International Geological Congress (1913) was 7,373,461 million tons.

main producing countries are set out in the table below. The figures given include only 'known' and 'probable' reserves: no account is taken of 'possible' reserves, the existence of which has not yet been tested by systematic drilling.

COAL: RESERVES AND ANNUAL PRODUCTION[1]

(In thousands of million long tons)

Area	Anthracite and Bituminous	Lignite and sub-Bituminous	Total Reserves	Production 1948
U.S.A.	1,340	1,840	3,180	·584
Canada	63	36	99	·016
Alaska	500?	500?	1,000?	n.a.
Great Britain	175	0	175	·207
Germany	128	51	179	·163
France	20	2	22	·044
Belgium	10	0	10	·030
Poland	45	9	54	·074
U.S.S.R. (Europe)	60	10	70	·204
,, (Asia)	150	200	350	
China	228	3	231	·019 (1947)
Japan	7	1	8	·036
Indo-China	20	0	20	·0003
India	50	20	70	·030
Australia	14	38	52	·022
South Africa	10	12	22	·024
Other Areas	25	25	50	n.a.
World	2,845	2,747	5,592	1·485

The figures given in this table vary considerably in reliability. The Alaskan figures, for example, are based on relatively little evidence and are included only because the possibility of so

[1] The figures of reserves are based on those prepared through the International Geological Congress, 1913. They have been modified in the light of subsequent estimates prepared by M. R. Campbell (for U.S.A.), J. A. Allen (Canada), R. Lawrence (Alaska), the Polish Geological Institute, C. S. Fox (India), W. J. Wybergh (South Africa), the Australian Royal Commission on Coal, the Chinese Geological Survey, and officials of the U.S.S.R. Allowance has been made for coal extracted after the date of the estimates. Alsace is included in France, but the Saar in Germany, in order to preserve the comparison with production. (The production figures are taken from the United Nations Year Book.—*J.R.*)

great an addition to the world's resources cannot be overlooked: the actual figures may well suffer the fate of the Canadian estimates, which were reduced from 1,200 billion tons in 1913 to less than one-tenth of that amount in 1947. Estimates of the 'coal workable at the present time' in Canada amount to less than 100 billion tons, about one-third of which is lignite and most of the remainder is 'young' bituminous coal of the cretaceous era, which is of poorer quality, more difficult to work, and more difficult to estimate, than anthracite and bituminous coal of the carboniferous era, such as is found in Britain and Belgium. The Alaska reserves, and about half of those of the United States, belong to the cretaceous age, and the irregularity of these measures must, in any case, make them difficult to estimate. The figures for the United States, however, like those for the European countries, may be taken as fairly reliable. Those for Siberia, India and China are based on surveys which are admittedly inadequate. The U.S.S.R. possesses 60 billion tons of black coal and 10 billion tons of brown coal in Europe, but the Siberian estimates will remain little more than informed guesswork until the coalfields themselves are more fully developed. At present, the U.S.S.R. derives 85 per cent of her coal from Russia in Europe. In India, recent surveys of the good-quality, easily accessible coal, agree on 5 billion tons: the coal is of fair quality but like the Australian, South African and South American coal it gives a high percentage of ash. Estimates for China vary considerably, and it seems unlikely that reliable figures will be forthcoming for some years.

In view of all these uncertainties it would be unwise to regard the world total of six million million tons as anything more than a very rough estimate indeed, and it would certainly be rash to say that the world has enough coal to last 3,700 years at the present rate of extraction. The world's main demand is for 'black' coal (anthracite and bituminous) rather than 'brown' coal, which is unsuitable for many of the purposes for which black coal is used. A good anthracite contains twice as much carbon as lignite and has double the heating value. The amount of black coal consumed in 1937 was five times the amount of brown.

Two other considerations ought to be taken into account before attempting to estimate how long the world's supplies will last. The first is that some vast deposits may prove to be almost completely unworkable because they have been folded and crushed by geological disturbances: in China, for example, intense folding has rendered considerable areas completely useless. Another difficulty is that some deposits—in Alaska, for example—are so placed that natural conditions, even more terrible than those of Spitzbergen, are likely to discourage any attempt at large-scale exploitation, whilst others, for instance in China and the U.S.S.R., are so remote from the seaboard and from other mineral deposits that they are unlikely to play any major part in the world's commerce. China will almost certainly import, rather than export, coal for many years to come.

If we ignore the difficulties of transport, and merely subtract from the world's total of black coal the figure for Alaska and half the figure for China, as well as reducing the Indian and Canadian figures to those already mentioned, we arrive at something a little over two million million tons as the world's available stock of anthracite and bituminous—enough to last 1,600 years at the present rate of consumption.

There is one more major point to consider. A good deal of coal always has to be left in the mines as supporting pillars, as barriers against fire and water, and support for buildings, roads and railways. Anything from 25 per cent to 50 per cent may be lost in this way. Much depends on the method of extraction: in some Australian pits, worked on the pillar-and-stall system, only 30 per cent to 40 per cent of the coal can be extracted; elsewhere, in seams of moderate thickness worked by the long-wall method, the percentage may be nearly 100, but in workings mechanized on the three-shift system, less than 90 per cent is extracted. The average figure, in a well-organized pit, is about 60 per cent, so that the available reserve of black coal is reduced to about 1,200 billion tons. The available reserve of brown coal is likely to be about the same.

When all these factors are taken into account, one sees that it would be exceedingly rash to assume that the whole of the

world's supply of coal is available for extraction and use. Deductions must be made for poor quality, geographical inaccessibility, difficulty of extraction, and loss in mining. If we take all these factors into consideration, the total amount which can ultimately be brought to the surface may be as little as 2,000,000 million tons. C. A. Carlow, in *World Coal Resources* (1946), says: 'The inevitable conclusion is that, apart from some notable exceptions, the coals which can be relied upon as being of the quality necessary to withstand economic competition in the world's markets, are to be found in the carboniferous formation, and, what is very important at the present rate of extraction, the best of these will become scarce in less than a hundred years.'

The position will be complicated by the coming decrease in the world's output of oil. Over the last ten years the U.S.A. has derived about 50 per cent of its heat and power from coal, 40 per cent from oil and natural gas, and 10 per cent from water-power. If the citizens of the U.S.A. are not to accept a lower standard of living and gadding-about, they will have to replace natural petroleum by synthetic, and this will mean that merely to maintain present standards the annual consumption of coal will have to be raised to about eight tons per head. If everybody in the world used as much coal as this, and the world's population remained stationary, the world's supply of extractable coal would be used up in 115 years.

Several points of interest emerge from the detailed figures: the immense strength of the American position, with enough good coal to last over a thousand years at the present rate of extraction; and the relative strength of the British position, with coal to last (on the same basis of calculation) at least 500 years. The British coal measures may not be a large fraction of the world's total, but the coal is of very high average quality; it is easily extracted, and is readily available for transport. Britain, Germany and the United States are the only countries which can afford to export coal in considerable quantities. Canada has enough for her own needs, though it is inconveniently placed and imports from the States are likely to continue. South America, with a total reserve which is only equal to a year's

output in Great Britain, must obviously be severely handicapped in the development of its industry. Canadian shortage of reserves is startling in view of earlier optimistic estimates. Even for Canada the figures now accepted make it plain that there are limits to industrialization and to the total population which the country could support over a long period. Nevertheless, Canadian resources are greater than those of any European country except Britain, Germany and Russia.

The Russian position (taking into account the Siberian reserves) is strong; but the reserves per head of the population are only a half of those of Britain and less than a tenth of those of the U.S.A. The picture of China and India as great thriving industrial countries, as prosperous as the U.S.A. and with three times as many people, is a dangerous fantasy. If these countries attempted to become as heavily industrialized as the U.S.A., basing their economy on coal, they would be ruined within a century.

For the present, Britain and the United States could well afford to increase their present output. Brown coal, of which there are such vast supplies in the United States, and which made up half the output of Germany before the war, might well be made the raw material for the manufacture of synthetic oil. Given only a modest increase in the world's population, and an equally modest increase in the consumption of coal per head, the world need not begin to worry about the difficulties of mining below 4,000 feet or the rigours of a pitman's life in Alaska for another hundred years; but if we wish to entertain the hope that within a few generations the vast population of Asia will enjoy the same standard of mechanical comfort as the United States or western Europe, we must look to something other than coal as the source of power.

Water-power

The water-wheel is one of the oldest of our mechanical devices, and in some measure it is used throughout the world. Even the astute Tibetans, who have hitherto refused the advantages of a mechanized civilization, have long used water-power

to rotate their prayer-wheels at a speed unobtainable by ordinary physical and spiritual effort. In spite of the ubiquity of the water-wheel, however, no appreciable fraction of the available energy was used until after the invention of the turbo-generator, for the problem is not merely to generate power, but to transport it to the point where it is needed, and this can be done only by electricity.

The amount of energy available from water-power at a given point depends, of course, on the time of year, and is fairly easy to calculate. The figures given in the following table represent the horse-power which could be maintained steadily throughout the year without deliberately raising the level of the water and equalizing the flow by constructing new dams on a large scale. The effect of dams already built or already planned has, however, been taken into account.

WATER-POWER, ACTUAL AND POTENTIAL—I
(In million H.P.)

	Developed h.p. 1930	Developed h.p. 1945	Potential h.p. at minimum flow
Europe	18·4	30·1	73·8
North America	21·8	35·5	81·2
South America	·9	2·0	66·6
Africa	·033	·24	273·9
Asia	4·03	8·7	150·6
Oceania	·37	1·3	20·1
World	45·6	77·9	666·2

By 1930, the world was using 7 per cent of the steady power available; by 1945 about 12 per cent. In Europe and North America, over 40 per cent of the available steady power was already developed by 1945. In that year the equipment already installed in Canada and the U.S.A. was enough to give the whole population nearly a quarter of a horse-power per head.[1]

[1] An average labourer—or a man riding uphill on a bicycle—can work at the rate of about one-seventh of a horse-power. In 1945, the power derived from other sources (coal, oil, etc.) in the U.S.A. was about $1\frac{3}{4}$ h.p.

There is scarcely enough steady water-power in the world to give all the world's inhabitants quite so much.

The horse-power which will ultimately be installed will no doubt be greater than the maximum given in the first table: during the six months when a river is flowing at its fastest, it would probably give nearly double the 'steady' power which it could give all the year round; and the output could be increased still more by the construction of major dams intended to raise the water-level to a height that would make the installation of power-plant profitable where at present it would not be worth while. (In Italy, the horse-power of the turbines installed already exceeds possible output of energy at ordinary minimum flow.) If we are to assess the world's total reserve of water-power and compare it with what has already been achieved, we must make adequate allowance for the new reserves of energy that could profitably be tapped by the construction of dams and artificial lakes, on the assumption that fields and forests will not be drowned to make a reservoir if their present value to the com-

WATER-POWER, ACTUAL AND POTENTIAL—II
(In million H.P.)

	Developed h.p.			Potential Economic h.p.
	1930	1936	1945	
Canada	6·2	7·6	10·3	70
U.S.A.	13 8	16·3	24·2	100
Europe	18·4	27·2	30·1	180
Australia New Zealand	0·37	0·6	1·3	15
India	n.a.	0·6	0·7	100
U.S.S.R.	n.a.	1·5	1·1	40
World, including other regions	45·6	60·0	77·9	1760

munity is greater than their value as a source of power.[1] In the second table, the 'potential economic horse-power' represents the maximum output which might be expected with the construction of major works of civil engineering.

The maximum is impressive, but the rate of progress towards the local maximum in some regions is already startling: in Canada and the U.S.A. the output has increased by 70 per cent in fifteen years. If their development were to continue at this rate, the whole of their water-power would be harnessed by 1980; and if development were equally speedy elsewhere, the whole world's supply would be in use within eighty years. There is, of course, little prospect that this will happen. The scale and cost of recent enterprises such as the Grand Coulee Dam in the United States shows that the easier schemes have already been developed. Any further advance will call for greater accumulation of capital and it is doubtful whether the world will be willing, in the next twenty years, to put aside 10 per cent of its income for capital development as it did in the early part of this century. The day when the rivers of the world can be made to supply us with one h.p. per head is still remote.

There is, perhaps, one other way in which our resources of water-power could be augmented. Here and there on the world's surface there are great depressions into which the water of the sea could be allowed to flow: when the resulting artificial lake had reached a certain size, the intake would be balanced by evaporation, and the steady flow of water could be used to provide power. The 250-foot difference in level between the Qattara Depression and the Mediterranean, utilized in this way, could provide power for a large part of the Nile valley.[2] In Palestine, the water flowing into the Jordan is needed for irrigation; and if it were used for this purpose the level of the Dead Sea could be maintained by bringing in sea-water. The difference in level

[1] This is one of the points at which there is a clash between the claims for energy to support a 'higher standard of living' and for land to support a larger population. Every dam constructed in a fertile valley reduces the number of people which the world could support at subsistence level.

[2] John Ball, 'The Qattara Depression', *Geographical Journal*, Vol. LXXXII, No. 4. October 1933.

is over 1,200 feet, but the difficulty and expense of cutting a tunnel through forty miles of porous rock would be considerable. (The Qattara scheme is open to the same objection.) Again, the Danakil country, part of which is 300 feet below sea-level, might be used to supply electric power to Ethiopia and Eritrea.

None of these schemes would make as much as 1 per cent difference to the world's total resources; the initial outlay of labour and material would be enormous; and the installations would not last for ever. Gradually the lake would fill up with silt, just as some ill-conceived reservoirs in Africa and the United States (such as the Awash reservoir, constructed by the Italians, near Addis Ababa, and Lake Como in Minnesota) have already filled up with silt. The great rivers of the world will remain our chief source of water-power, though other schemes may help to solve local problems on a relatively small scale.

The development of water-power in Africa, Asia and South America still offers immense possibilities—the great untrammelled rivers of Papua, for example, which bring down an immense volume of water from a great height in a relatively short distance, could provide ten million horse-power—but water-power cannot be the major agent in the world's work if we are to aim at anything appreciably above our present standards: there simply is not enough of it, and much of it will cost more, in terms of present abstinence, than the world is yet prepared to pay. In Canada, where water-power is more highly developed than anywhere else in the world, it provides less than one h.p. per head of the population; in the U.S.A., coal and oil provide about seven times as much energy as water-power, and if all the water-power in the country were pressed into service it would only provide about half of the energy (from all sources) needed by existing works and factories. As a source of energy where coal is lacking, and as a standby for the day when coalfields become exhausted, water-power is of immense value; but in our time and our children's time its contribution to the world's work as a whole can never be anything more than minor: coal remains crucial.

Uranium and Thorium

A thousand miles beyond Edmonton, far up towards the Canadian Arctic, where the dark pinewoods crowd down to the shores of the Great Bear Lake, there has grown up since 1930 a group of buildings congregated round an 800-foot mine-shaft. This is Port Radium, and the shaft is the Eldorado Mine. It was in 1900 that Mackintosh Bell and Charles Camsell—the first white men to enter Great Slave Lake since the Franklin Search Party of 1854—saw a yellow stain on a rock beside the lake. Thirty years later, Gilbert Labine read their report, and recognized the signs of pitchblende (uranium oxide), the main source of radium. Through Labine's energy, Canada was producing, within a few years, nearly half the world's supply of radium. The crude ore contains one gramme of radium to a thousand tons. At Port Radium, the crude ore is concentrated and shipped 2,000 miles to a refinery at Port Hope, Ontario. In 1939, the mine was producing 126 grammes of radium a year.

For every gramme of radium, however, the ore contains three tons of uranium, and the subsequent development of processes for the use of atomic energy gave a new importance to the uranium which had been a byproduct of the extraction of radium. Minute quantities of uranium are widely distributed in many kinds of rock, the average content being about four grammes per ton. The total amount in the earth's ten-mile crust is thus about 100 million million tons. But at present, only the richer ores can be extracted, and these are comparatively rare.

In 1939, the world's production of uranium amounted to about 1,000 tons a year, of which 400 tons came from the Great Bear deposits (estimated at 7,000 tons) and most of the remainder from the mines of the Katanga Company in the Belgian Congo (whose deposits are estimated at 11,000 tons). Workable ore of a similar kind is found at Joachimsthal (Czechoslovakia—an estimated deposit of 1,500), at Schneeberg (Saxony) and in Portugal. In 1940, the Eldorado Mine was on the point of closing, because the stocks of uranium exceeded the world's needs. At one time, veins were worked in Cornwall. Deposits have also

been found at Mount Painter (South Australia) and near Sofia (Bulgaria). Other minerals rich in uranium are found in Ontario and Quebec, and in New England, South Dakota, Texas, Madagascar and southern Norway: and the element is found in association with vanadium in Colorado, Russian Turkestan and the Caucasus. The Cambrian Shales of southern Sweden yield an ash containing up to 2 per cent of uranium oxide.

The other element useful for the production of atomic energy is thorium. Like uranium, minute quantities (up to ten grammes per ton) are widely distributed in rocks, but the chief workable sources are the monazite sands of India, Ceylon, Brazil, north Carolina, Idaho and Florida, which yield from 6 to 10 per cent of thorium oxide. So far it has not been used to produce atomic energy, but developments to make this feasible are likely in the near future.

For experimental purposes, there are adequate supplies of uranium in the pitchblende deposits of the Great Bear Lake and of the Belgian Congo; but whether these deposits are large enough to supply uranium for the serious commercial development of atomic energy is more doubtful. If atomic energy is ever to become a major source of power, it will be necessary to devise chemical processes for the extraction of uranium from low-grade ores. Perhaps such processes have already been discovered.[1]

Assuming that adequate supplies of the raw material are available, the use of energy derived from atomic fission is well within the bounds of commercial possibility. Mr. Bernard Baruch, in a report to the Atomic Energy Commission, estimated that a nuclear reactor could be built to generate at a cost only about 25 per cent higher than the cost of power generated from coal, taking the price of coal to be seven dollars per ton.

The cost of nuclear energy will depend not so much on the primary cost of the ore (though this will increase as lower-grade ores have to be used) as on the cost of the subsequent treatment; and the important question is whether sufficient supplies of

[1] It was announced late in 1950 that uranium is to be produced by four South African gold mines, though the concentration of uranium is low in the ores they mine compared with the uranium content of the ores hitherto treated.—*J.R.*

uranium and thorium are available for any large contribution to the world's power supply. The world's total consumption of energy at present is equivalent to about four million million kilowatt hours of electrical energy. This quantity could be supplied by the complete fission of 200 to 250 tons of uranium or thorium a year. The processes at present made public, however, utilize only the energy set free by the fission of uranium 235, which forms less than ·2 per cent of natural uranium; so that present methods would need more than 100,000 tons of uranium a year to equal the world's present output of energy. Even if, as seems probable, new processes make it possible to use a far bigger proportion of the uranium, 10,000 to 12,000 tons of uranium would be needed every year.

This quantity, though minute in comparison with the world's total supplies, is large in comparison with the known deposits of high-grade ore. The cost of extraction from the lower-grade ores, and the cost of disposing safely of the vast quantities of radio-active byproducts of fission, is likely to keep the cost of nuclear energy fairly high. Atomic energy may supplement the energy derived from coal and water-power, but on present showing it seems unlikely to replace these resources or to lead to any appreciable reduction in costs.

Other Sources of Power

From time to time other sources of power have been proposed, and even used. The use of wind-power, for example, is as old as the first sailing ship and as modern as the latest windmill. There is the heating-power of the sun's rays: experimental power-plants have been set up in the Sudan and elsewhere, and only their high initial cost and equally high cost of upkeep render them unsuitable for general use. There is the immense power of the tides, which here and there is harnessed by the construction of barrages across the mouths of shallow estuaries. There is the electrical power stored up in clouds: the American Meteorological Society was told, at its meeting in April 1934, that one thousand million kilowatts of energy was poured down on the earth every year by thunderbolts. Goodness knows what this

means. The kilowatt is a unit of power, not a unit of work.

Speculation on these subjects is entertaining but useless. The experimental work which has been done shows that the harnessing of energy from these sources (if we are to work on a large scale) is extremely expensive in terms of capital equipment and will not be a practical proposition until we have far more energy available from other sources than we have at present. In order not to be behindhand in wildcat speculation, however, we may point out that the total energy stored up in the heat of the earth's interior is at least 10^{27} kwh.—enough to keep the world's machines going for a hundred million million years—and that the energy reaching the earth's surface from the sun every year amounts to $3 \cdot 10^{15}$ kwh. At present the only part we use is that which lifts the rain to the mountain tops or which was stored up in coal in past ages; but if we could use the whole of it, this solar energy alone would give 4,000 million people 100 h.p. per head: the earth would, of course, grow cold underfoot, the sea would freeze, and humanity might well decide to switch off the machines and look at the sun. It might be better to make use of those resources which depend on the rotation of the earth on its axis. Thus, if we harness the tides, we gradually lengthen the day. If we could devise and construct suitable machines, we could supply twice the present population of the world with 100 h.p. per head for a quarter of a million years before the earth finally came to a stop.

It is easy enough to spin fantasies around such immense figures, but the hard fact of engineering is that before we can begin to tamper with the heat of the earth's interior, or the sun's radiation, or the energy of the tides, on any reasonably big scale, we are going to need two or three times the energy at present available in order to build the shafts or thermo-electric piles to enable us to do it. For the next half-century, coal, oil and water-power (with some help from atomic power if extraction processes can be cheapened) must be the main sources of the energy that will enable us to live in greater comfort or to develop those areas of the world which are at present not worth the cost of cultivation.

Horse-power per head

Broadly speaking, man can lighten his burden of mechanical work only by making animals and machines work for him. The figure we have already given as the total of the world's mechanical work—about four and a half million million kwh. per year, or 12,000 million kwh. per day—is equivalent to about 7 h.p. per day per person. Putting it another way, we may say that to keep things running as at present requires, day and night, a steady output of a little over a quarter of a horse-power per person.[1] This output of energy is derived from human and animal labour, and from the world's annual production of 1,500 million tons of coal, 3,500 million barrels of crude oil, and 600,000 million kwh. of electric power. It is, however, very unevenly distributed: a rural family, owning a beast of burden, can keep up the equivalent of a steady output of rather less than one-tenth of a horse-power per person, and the greater part of humanity do not even own a share in a horse or donkey or camel. Even among the countries using steam- and petrol-engines and hydro-electric power, there is great disparity between, say, the United States, which uses 13·38 h.p. hours per head per day, and Brazil, which uses one-twentieth of that amount.[2]

If our aim was to raise the whole world to the present level of the United States, we would need a total daily output of mechanical and electrical work of 35,000 million kwh. By harnessing all the world's available water-power, we could obtain 9,000 million kwh. per day. Petroleum, as we have seen, is a wasting asset, but for the present we could rely on 3,500 million barrels a year, which would provide another 1,750 million kwh. per day. The remaining 24,250 million kwh. per day would

[1] It has been calculated that the daily output of work in 1932, from all sources—human, coal and oil, water—was, in terms of h.p. per head: United States ·557, Canada ·544, Norway ·316, Great Britain ·277, Germany ·251, France ·181, Argentine ·070, Brazil ·026, India ·020, China ·019. (Based on calculations by Dr. T. T. Read in *American Economic Review*, Vol. XXIII, March 1933).

[2] See Appendix B, Table XIII: Output of Electrical Energy.

have to be provided by coal, and this would need 15 million tons of coal a day, or 5,500 million tons a year, which is more than three times the world's present output.

Of course, it is most unlikely that any such general increase in the standard of living will occur; but the calculation shows plainly that any Utopian scheme for the widespread betterment of humanity depends either on the development of new sources of power, or else on a reduction in the world's population. It should be noted that the standard set is not really a high one: there is a good deal of poverty even in the U.S.A., and no American citizen would be happy to think that the present standard of living of his country represented a maximum which might be maintained for a little more than a century. Americans may be willing to barter some of their coal, and some of the manufactures to which it gives rise, for goods from abroad (and we have already seen that they will soon need to import more and more food), but it is most unlikely that they will give away their coal on a sufficiently large scale to make a radical difference in the standard of living of other people. To envisage a state of affairs in which the world's coal consumption would be double or treble the present figure is speculative but not unreasonable, but the whole idea of a Wellsian world in which we all live on a £30,000 a year level is crazy—there would not be enough coal and water-power to run the machines for us unless we drastically reduced the world's population.

In the past thirty years, the world's output of coal per head of the population has not risen;[1] indeed, in Britain and the U.S.A. there has been a marked decrease. The only country in which there has been a striking increase in output per head is the U.S.S.R.

There has, of course, been an increase in the output of energy derived from petrol and water-power; but even so, the total output per head has not continued to increase as rapidly as it did in the first ten years of the century in spite of the increasing efficiency of steam engines and internal combustion engines.

If we aim at doubling the world's output of energy per person,

[1] See Appendix B, Table XIV: Coal Output per Annum.

we must at least recognize that the difficulties are enormous. Something more than a doubling of the output of coal and petroleum and water-power might well be reached, for in the backward countries populations are still increasing and they will increase still more when more power becomes available for transport and agriculture. Technical improvements in the efficiency of our use of fuel might help, but there are fixed natural limits to the possibilities. The main burden would fall on countries such as Britain, the United States and the U.S.S.R. which have large reserves of good, accessible coal. It would be necessary to train millions of new miners and engineers, and the problem of skill which the 'advanced' countries are already facing would become still more acute. Can the world produce enough skilled workers to run the whole world on the same basis as the United States and western Europe? Can those countries themselves produce the doctors, civil servants, managers, engineers and other intellectual workers to run their affairs in the way they wish? Just as the problem of the world's food supply drives us to consider the problems of mechanical power, so the problem of work drives us to consider the world's resources of skill.

CHAPTER V

THE RESERVOIR OF TALENT

The Few and the Many

Between 1900 and 1940, through the effort and ingenuity of a few hundred men, the efficiency of the steam-turbine was more than doubled, with the result that more than 120 million tons of coal are saved every year in the production of electrical energy: the few hundred engineers have contributed more to the world's well-being than half a million miners. The contributions of other engineers and scientists are less easy to assess in terms of manual labour; and sometimes the best measure of their work is not labour at all, but land. The agricultural scientists who have increased the yield of grain per acre, or have discovered strains that will grow in climates hitherto unsuitable, have virtually doubled the world's area of cultivable land. The industrial chemists who invented synthetic rubber have set free six million acres—an area the size of Belgium—for the cultivation of other crops; even a comparatively small invention, the discovery of synthetic indigo, has saved a quarter of a million acres.

It is not 'the workers' who, in the past hundred years, have made possible the rise in the standard of living and the great extension of the world's habitable area, but a tiny group of engineers, scientists and explorers; and it is to that group that we must look for any further improvement. If the great mass of people continue to insist on their right to work less and to consume more, they must be prepared to give every opportunity to the small group on whose efforts they are wholly dependent for the achievement of their aims.

THE RESERVOIR OF TALENT

Already there is a shortage of talent: the industrial machine which we have built up calls for increased numbers of highly skilled technicians. The standards of health and well-being which we have set ourselves demand an increased proportion of dentists, medical officers and trained nurses. The process of finding the additional doctors and skilled mechanics makes it essential that we should employ more teachers. Britain, for example, aims at producing 50 per cent more scientists, graduate engineers and teachers, about 30 per cent more doctors and dentists, and 25 per cent more nurses. We all know one or two bus-drivers, waitresses or farmhands who, given the right training, might have done well in some more obviously intellectual calling. Are there enough people of this kind to go round?

The experiences of the fighting forces in the war of 1939–45 suggests that the shortage may soon make itself felt not merely on the higher levels, but in all the activities which call for a little more than average ability. In Britain, it became necessary to husband intelligence as carefully as steel or concrete. The mixed gun-teams on the A.A. sites, for example, often had to rely on male brawn and female brain: the intelligent, able-bodied men were all needed for other duties. And now, in peacetime, we are not only finding it difficult to fill the upper ranks of the Civil Service, but also being compelled to realize that it may not be possible to increase the number of women teachers without lowering the standard.

There is no substitute for intelligence: it is a commodity to be used as carefully as coal or land or water power, and before we plan any further development of social services, teaching and research, we need to ask ourselves what our resources are. How much intelligence *is* needed in a surgeon or an architect? How many people, possessing this intelligence and the other qualities necessary in an exacting profession, are at present employed on work that could be done by people not quite so bright, or that need not be done at all?

Precise answers may be impossible, but we can at least marshal the new facts that are available, and use them as the basis of tentative estimates instead of planning the future with the

reckless abandon of a child spending a birthday present ten times over.

The Measure of Intelligence

If by intelligence we mean the ability to learn and to apply the new skill or knowledge to new situations, it is certainly not the only quality needed in a good scientist or a good doctor: intellectual stamina is as important as native acumen. Common sense—that wise balance of experience, sympathy and impersonal judgment—is also needed, and there are few professions in which honesty and courage do not sooner or later become vital. To some extent, patience, modesty and conscientiousness can make up for a little stupidity; but nevertheless there is a minimum level of intelligence which is essential in each profession, and intelligence, in the narrowest sense, differs from other desirable qualities in two important ways. First, it appears to be more or less inherent and to be affected relatively little by training and experience. Secondly, it can be measured, or at any rate compared.

The earlier 'Intelligence Tests' were unsatisfactory, in so far as they were sometimes tests of knowledge and experience rather than tests of native ingenuity. Little by little, however, the linguistic and other extraneous elements in these tests have been reduced until they are now so small that they may reasonably be disregarded. By dint of much patient thought and learned study, the psychologists have devised tests which bear a close resemblance to the babyish achievements which make a mother say proudly: 'Isn't he clever!' Fitting square pegs in square holes, threading mazes, and stabbing little circles with a pin, these are the activities which are used as a general measure of intelligence. Of course, in testing men or women of the educated classes, say university students or Members of Parliament, it is fair to assume that they can read, and as long as the questions are posed in simple language and require only simple verbal operations as answers, verbal tests can be used without any grave danger of measuring the subject's literary knowledge rather than his Intelligence Quotient.

It is easy enough to make fun of the tests, but their justification lies in the fact that they work: that is to say, the same person, time after time, will gain about the same marks in the tests, and when the tests are applied to a group of children, the resulting 'order of merit' corresponds very closely to the general impression of a teacher who knows them well. The teacher is thus provided with a quick method of assessing the ability of a new child and of comparing the ability of his own group with that of other children he has never seen. There is no doubt that the tests are useful in this way; the trouble is that although they *compare* different intellects, they do not really *measure* them in the sense in which we can measure height or weight: there is no standard unit of brightness; we can take the average as 100, but who is to say whether Einstein is twice as clever or ten times as clever as the average? The index usually adopted in testing children is the 'mental age'. If Roger, aged ten, scores the same as the average child aged eleven, he is said to have a mental age of eleven. His 'Intelligence Quotient' is defined as one hundred times his Mental Age divided by his actual age: thus Roger's I.Q. is 110. Unfortunately, most people reach their maximum score in the tests at the age of fifteen or sixteen (perhaps because the tests themselves do not really test the more complex operations of the mature mind) and this would make the 'Intelligence Quotient' for adults an absurdity: it gives the impression that people become more and more stupid as they grow older, which is not invariably true. The Index of Brightness is free from this defect: it is simply one hundred times the ratio of a person's score to the average of his own age-group, all adults being treated as equals.

For our purposes, it does not matter what index is used to express ability. We merely need to range people in order of ability. The top 2½ per cent we shall call 'very able'; the next 7½ per cent 'able'; then 20 per cent will be 'moderately able'; 40 per cent 'average'; 20 per cent 'rather dull'; and the remaining 10 per cent definitely 'dull'. For brevity, we may call these six groups, A+, A, B, C, D, and E.

The minimum level for the A group is about the average for

the pupils in a good grammar school, and is well below the standard usually considered necessary in University students. The A+ standard is that of the fairly good University student.[1]

How Much Intelligence is Needed?

There is no clearly defined minimum of intelligence for any profession: it is doubtful whether a really dull man will ever make a satisfactory barrister or Permanent Secretary, and among Professors of Classics and Chess Champions, the percentage of A+ intellects is probably very high; but in other occupations tenacity, devotion, a powerful memory or some special aptitude will go far to compensate for a lack of native wit. These supplementary qualities are themselves rare; and it would be rash to assume that because 7 per cent of our trained nurses are of Grade E we could draw the whole nursing profession from that grade. If we are to increase the number of trained nurses without seriously altering the character of the profession, we must maintain the present ratio of A's, B's, C's, D's, and E's.

The important thing, therefore, is not to note the average I.B. for each profession, but the percentage in each grade. No one has yet determined the distribution of intelligence among civil servants, army officers, Members of Parliament and the clergy. R. B. Cattell's tests of teachers, doctors, engineers, and people engaged in a number of clerical and manual occupations provide some useful data. One has the more confidence in Cattell's results in that his assessments for student nurses appear to be confirmed fairly closely by the more elaborate tests carried out by the Working Party on the Recruitment and Training of Nurses which reported in 1947.

[1] It is not easy to express these categories in terms of I.B. or a modified form of I.Q. which is applicable to adults because although the *order* of the people tested remains much the same whatever set of tests is applied, the various systems of testing give slightly different numerical values for the same persons' I.B. or I.Q. In the tests conducted by R. B. Cattell, which we shall quote in our next section, the A+ group, or upper-fortieth, have an I.Q. of 154 or more. The A groups have an I.Q. between 137 and 154.

DISTRIBUTION OF MENTAL ABILITY[1]
(Percentage of Different Professions in Each Ability Group)

	A+	A	B	C	D	E
Graduate Teachers (in Schools, universities, etc.)	33	50	17	0	0	0
Science Graduates in Industry	28	50	21	1	0	0
Graduate Engineers	23	50	24	3	0	0
Barristers and Solicitors	21	54	23	2	0	0
Physicians and Surgeons	28	46	19	7	0	0
Dentists	21	38	32	9	0	0
Non-graduate Teachers	20	37	33	10	0	0
Ministers of Religion	13	35	37	13	2	0
Army, Navy and Air Force Officers	13	35	37	13	2	0
Civil Service (Admin., Dip. & Col.)	21	56	23	0	0	0
„ „ (Executive)	15	35	36	14	0	0
Nurses	4	12	24	36	15	9
Shorthand Typists	9	25	37	24	5	0
Architects, Chartered Accountants, Surveyors and Estate Agents	22	42	28	8	0	0
Whole Population	2·5	7·5	20	40	20	10

The table opposite gives the number of people employed in Great Britain in a number of occupations which demand a fairly high standard of intelligence. The fourth column shows the increases which had been officially proposed up to 1948, or which were plainly necessary to fulfil official plans.

We can now, by correlating these two tables, make a rough estimate[2] of the total number of able and very able people at present engaged in each of these occupations, together with the

[1] The figures for nurses are derived from the *Report on the Recruitment and Training of Nurses* (H.M.S.O., 1947). Those for graduate teachers, engineers, non-graduate teachers and shorthand typists have been obtained by re-casting the data given by R. B. Cattell in the *British Journal of Psychology*, July 1934. Others are estimates based on a comparison of the methods of recruitment. Direct test-results for these professions are not available, but the tests of the *children* of various professional classes, carried out by J. L. Gray and P. Moshinsky (*Political Arithmetic*, edited by Lancelot Hogben, 1938), throw some light on the matter.

[2] See Table on p. 84.

EMPLOYMENT IN GREAT BRITAIN, 1947
(In Thousands)

	Men	Women	Total to nearest 1000	Proposed Increase
				%
Graduate Teachers (in schools, universities, etc.)	27·4	19·1	47	50
Science Graduates in Industry	20		20	50
Graduate Engineers	30	0·1	30	50
Barristers and Solicitors	20	0·3	20	—
Physicians and Surgeons	50	5	55	30
Dentists	15	0·5	16	30
Non-graduate Teachers	44·2	128·8	173	50
Ministers of Religion	29	0	29	—
Army, Navy & Air Force Officers	70	1·4	71	—
Civil Service (Admin., Dip. & Col.)	3·6	·6	4	—
" " (Executive)	40·5	10·1	51	—
Nurses	12·6	155·5	168	25[1]
Shorthand Typists	1·0	100	101	—
Architects, Chartered Accountants, Surveyors and Estate Agents	50	·7	51	—
Totals	413·3	422·1	836	

number who would be engaged if the profession were increased to the extent proposed without any deterioration in its intellectual quality.

We are thus already employing about 134,000 men and women of A+ calibre in these professions and our plans for expansion call for nearly 40,000 more. All these must be provided by the upper fortieth of our total adult population. In Britain, in 1947, there were about 14 million men between the ages of twenty-one and sixty-five, and about 15 million women. Assuming that intelligent people stand as good a chance of survival as anybody else, this gives us 350,000 men of A+ intelligence and

[1] *The Recruitment and Training of Nurses.* H.M.S.O., 1947. (No reference was given to the source of the other estimates of increase, but the figures for teachers and science graduates are borne out by the Ministry of Education pamphlet, No. 2, *A Guide to the Educational System of England and Wales,* and by the Barlow Committee's Report on *Scientific Man-Power,* 1946. Cmd. 6824.—*J.R.*)

TALENT IN VARIOUS PROFESSIONS
(In Thousands)

Profession	At Present		Proposed	
	A+	A	A+	A
Graduate Teachers	15·3	23·2	23·0	34·9
Science Graduates in Industry	5·6	10·0	8·4	15·0
Graduate Engineers	6·9	15·1	10·4	22·6
Barristers and Solicitors	4·3	11·0	4·3	11·0
Physicians and Surgeons	15·4	25·3	20·0	32·9
Dentists	3·3	5·9	4·2	7·7
Non-graduate Teachers	34·6	64·0	51·9	96·0
Ministers of Religion	3·8	10·2	3·8	10·2
Army, Navy & Air Force Officers	9·3	25·0	9·3	25·0
Civil Service (Admin., Dip. & Col.)	0·9	2·4	0·9	2·4
„ „ (Executive)	7·6	17·7	7·6	17·7
Nurses	6·7	20·2	8·4	25·2
Shorthand Typists	9·1	25·3	9·1	25·3
Architects, Chartered Accountants, Surveyors and Estate Agents	11·2	21·3	11·2	21·3
Total	134·0	276·7	172·5	347·2

375,000 women. Subtracting the A+ men and women on our present lists, we are left with about 270,000 men and 325,000 women to produce our 40,000 recruits to the professions listed above. Or our problem may be defined in this way: if we are to increase the proportion of scientists, doctors, engineers and teachers in the way suggested without lowering the standard in any of the occupations on our list, we must find 40,000 very able recruits among the 600,000 very able people who do not appear in the above lists at all.

If the present ratio of men to women is to remain unchanged, we must find 22,000 men out of the pool of 270,000 men and 18,000 women out of a pool of 325,000. The problem ought not to be insoluble, but three difficulties present themselves. First of all, many of the men and women in the pool, though equal in mental capacity to the best of our present doctors, teachers and

engineers, do not possess the other qualities of character and temperament needed in these exacting professions. Secondly, a considerable number of our A+ boys and girls do not at present reach a secondary grammar school at all, either because our selection for admission to the grammar schools is faulty, or because the children lack the application and intellectual stamina necessary if 'intelligence' is to be converted into achievement. Finally, some of those who *do* possess all the requisite qualities, and *do* succeed in making their way to a grammar school, nevertheless have a strong inclination to become farmers, or merchants, painters or musicians. In practice, the pool of very able men, available to supply our 22,000 additional teachers, doctors, engineers and scientists, probably amounts to little more than 100,000, most of whom are already engaged in useful work. The country is demanding that 22 per cent of its most able industrial managers, local government officials, engineering draughtsmen, authors, journalists, entertainers, M.P.s and trade union leaders should turn to some other profession.

Stated in that way, the prospect is not encouraging: the country simply cannot afford any marked reduction in the ability of its draughtsmen, managers and political leaders. One looks eagerly for help in other directions. One obvious step is to recruit a bigger proportion of women into certain of the professions. Another is to reduce the wastage of high intelligence in the primary schools, and to intensify our efforts to foster in the abler children all those qualities of character needed in a professional career. Both solutions have their disadvantages as well as their difficulties. We do not want to debar all our abler women from marriage and motherhood; and we have to face the fact that it is not easy for a mother of three to follow an exacting profession whilst giving due attention to her children unless she is given adequate domestic help. Some reversal of the general trend away from domestic service would be necessary. Again, if we succeed in our efforts to make doctors, teachers and engineers of some of the boys who at present become policemen or fitters or farm-labourers we shall create a much more rigidly stratified society than at present and deprive

these groups of the best of their leaders and spokesmen. This organization of society so that a man's occupation would be a true index of his intellectual capacity would have some disquieting political implications.

There is little doubt that the British, in their efforts to increase the proportion of professional workers, will be compelled to do a little of all three. They will depress the quality of the managers and draughtsmen (and perhaps of their clergymen and army officers, too), they will bring more women into the professions, and they will skim off still more of the cream from the class of skilled artisans. Probably, they will also be compelled to accept a slightly lower standard in the undermanned professions. In order to make sure that no suitable person is missed, the opportunity to gain a professional training will be given to much greater numbers (this will itself intensify the need for able teachers) and among the 'doubtful' students there will be an increased proportion of casualties who will have to go back to some occupation for which they are better suited.

It thus seems that the present plans could be fulfilled with only a slight lowering of standards, but that any further expansion of professional services requires either a general lowering of standards or else an all-round improvement in the intelligence of the population.

The Decline of Intelligence

Machines are run on coal, oil, water-power and brain-power. As the output of energy per head increases, so the demand for physical labour falls and the demand for intelligence rises, until the sub-normal become parasites on those who have the wit to control intricate processes and to make and mend complex machines. At a certain stage of mechanical development, those whose intelligence is below the average can be usefully employed on simple repetitive tasks, but little by little those simple operations are themselves mechanized, and one skilled worker replaces three dull ones. For the time being, we may find enough engineers and scientists by searching the ranks of the skilled mechanics; we may increase the number of doctors and higher

civil servants by recruiting more women; but measures of this kind will not help us to dispose of the redundant dull-wits. The only general solution is a general increase in intelligence. And just at the moment when this increase becomes necessary, we are in fact taking active steps to lower the average standard.

For many years now, writers such as Cattell in England, and Frederick Osborn in America, have pointed out that the sections of society which are increasing in numbers are those which have the lowest intelligence. An extract from one of Cattell's tables[1] will show the tendency:

FERTILITY AND INTELLIGENCE

Occupation	I.Q. of Children	Size of Family
Unemployed	81·7	4·25
Farm Labourers	82·2	4·05
Unskilled Labourers	93·6	3·84
Unskilled Factory Workers	97·8	3·44
Farmers	98·8	3·80
Skilled Labourers	98·8	3·53
Shopkeepers	101·7	2·83
Skilled Factory Workers	102·2	3·23
Clerks	109·3	2·43
Engineers, Teachers, Doctors	116·0	2·29
Business Owners	116·5	2·57

The general trend is unmistakable: the groups which produce the dullest children are multiplying rapidly, whilst the more intelligent groups are not producing enough children to replace themselves. If the process were to continue at the present rate, the average I.Q. of the nation would decrease by about one point every ten years, and the able or very able group which makes up 10 per cent of our population now would make up only 8 per cent in the next generation. The average level of intelligence is not rising but falling, and falling fairly rapidly.

At this point, one turns hopefully to the view that intelligence is, after all, the product of environment and not of heredity.

[1] From *The Eugenics Review*, Vol. XXIX, No. 3. October 1937.

Perhaps the children of the least intelligent groups would be brighter if they were brought up in better surroundings? Careful observation offers little ground for hope on this score: the intelligence of adopted children, for example, can be correlated more closely with that of their parents than with that of the class into which they are adopted. Intelligence may make a better showing in better surroundings, but native endowment sets an upper limit to possible attainment. In equally good surroundings, it is the children of the brightest parents who do best. There are only two facts from which we can draw any real consolation. The first is that children do not inherit exactly the same intelligence as their parents: some are brighter, some duller, so that even a race of dullards would still produce some very able people. The second is that the *average* intelligence of the children seems to be intermediate between that of their parents and the average, so that if our present selective breeding of the dull-witted were abandoned, the distribution of intelligence might gradually work back to normal. (Similarly, if by selective breeding we built up a more intelligent race than at present, there might well be a tendency to work back to the present average if the selective breeding were abandoned.)

How serious the position really is, one cannot say. After all, the evidence of decline is indirect, and direct comparisons of the children of to-day with those of thirty years ago are difficult. One can only say with Dr. Frederick Osborn: 'Many people believe that there is strong presumptive evidence that an adverse selection of genes is going on under our present environment. I do not accept this thesis nor do I reject it. I simply do not know. But I do know that under the present conditions of low mortality and wide differentials in birth-rates, it is possible for the quality of the race to change with startling rapidity. It would be nice to know what sort of change is actually going on.'[1]

It would indeed. All that one can say with fair certainty is that the average level of intelligence is not increasing, and that the percentage of people with high ability is not increasing. If a

[1] In an address, 'Is Eugenics Practical?' given to the Cooper Union Forum on 2nd March 1948.

nation refuses to make any effort to increase its stock of available intelligence, and still more if it deliberately reduces the death-rate among the poorest strains and encourages them to breed rapidly, it will either have to reduce its own need for intelligent workers or else accept increasing inefficiency in government and industry.

The Economical Use of Intelligence

For the next thirty or forty years (and perhaps even longer if the differential birth-rate is not reversed) Britain and the U.S.A. are going to find themselves short of the intelligent people who are needed to run their complex industrial systems. It will be of vital importance to make the best possible use of the limited resources available: difficult tasks, requiring judgment and acumen, will have to be reduced to rule-of-thumb, and work will have to be so organized that the individual has every opportunity and every incentive to make the best possible use of his brains.

In some professions, a certain amount of standardization is possible. In medicine, for example, the division of the profession into general practitioners and consultants might be carried one or two stages further: in addition to the present specialists, there might be one group (of fairly high intelligence) concerned with preliminary diagnosis, and two or three other groups concerned with treatment, the lowest group dealing only with simple, straightforward cases. The prospect is intensely unattractive, and such a scheme would not be easy to work, but a country which is over-spending its intelligence will be reduced to some such device, though the change will probably come about gradually, without anyone ever taking a decision in its favour.

In architecture and engineering, too, some economy on these lines is possible; it may produce a duller, cruder world, but even that may be better than a world which is increasingly incompetent. Teaching has its peculiar difficulties: it is plainly undesirable that a teacher should be markedly less intelligent than the brighter children in his class, and the teaching of sub-normal children calls for even more intelligence than the teaching of normal children. One obvious defect in our present system could how-

ever be remedied fairly easily. At present, the primary and secondary modern schools in Britain are mostly organized on the class-teacher system, so that a bright child may have to put up with the same relatively dull teacher for a whole year: the subject-teacher system of the grammar schools, on the other hand, gives every child a sporting chance of meeting four or five times a week a teacher who will really extend his powers and fire his imagination. There is no reason, except the conservatism of the profession itself, why the system should not be extended to all but the very smallest schools.

The real problem, however, is in the field of industry—and economics. Britain in 1945 deliberately decided that the development of a large part of her industry was to be planned and not left to the hazards of free enterprise. In some matters (notably land-conservation in the eroded areas) the United States is being driven to a similar decision. This may be all to the good (and it is difficult to argue against the case for centralized control in areas that have been badly farmed), but there is a considerable price to pay. Under free enterprise, the individual used his native wit to the best of his ability, and the level of prices showed the direction in which further effort would be profitable. One did not need to be a statistician to deduce that a steady rise in the price of wheat implied that more wheat would be welcome. Substitute fixed prices, subsidies, quotas and rationed consumption for the give and take of a free market, and you need a small army of highly intelligent, highly trained mathematicians, mass observers, agricultural experts and dieticians to discover what on earth the real position is. The final result may sometimes be better than the operation of a free market; but on the debit side of your account you have to enter all the skilled intellectual workers withdrawn from other useful jobs. The fact that a farmer has to substitute a nightly struggle with departmental forms and dockets in place of the simple pleasure of looking at his pass-book and reading up the fat-stock prices in his local paper is also relevant, but is less likely to be overlooked. The farmer will hold indignation meetings, or write 'Go to Hell' across official forms: the experts,

bribed with good pay and flattered with their new-found sense of power, are less likely to point out that they might have been doing more productive work if they had not taken over the job of the broker and the auctioneer.

Again, the 'organization' of any profession implies the appointment of boards, committees and tribunals. One sees in *The Times* (24th April 1948) that five live dentists have been nailed down to a Dental Board. The ultimate result may well be to give us more dentists, or to use those we have more effectively, or even to make dentists less necessary; but for the moment the five are a dead loss to the community. Similarly, the gay habit of demanding a Royal Commission every time a bus-driver runs over a dead cat leads to endless waste of valuable time. In industry, Joint Production Committees may give the employees the feeling that they are really helping to direct the business: the managerial staff merely notice that if they have to give up 20 per cent of their time to attendance at a Debating Society, they need five men to do the work of four.

Committees, boards and conferences may well produce positive results; but in every case we ought to ask 'What is the cost in A+ man-hours?' A country which is short of intelligence simply cannot afford to make a reckless use of its brain-power; to count only the gains and to ignore the cost is silly at all times, and may be fatal in the present circumstances.

There is little doubt that competent, well-informed and reasonably unhurried planning can, in many fields, produce better results than haphazard competition, but the cost is far higher than people have yet realized and the penalties for incompetence far more severe: in place of individual bankruptcies and large-scale unemployment one has the possible breakdown of a whole country. The amount of planning which can be undertaken depends on the amount of brain-power available, and if a country wishes to go in for large-scale planning, its first step should be to increase its supply of available intelligence. If it does not do so, and if on the contrary it uses its social services and industrial organization to increase the proportion of subnormal intellects in the population, it will escape the old trade-

cycle of boom and slump only to find itself incomprehensibly involved in a far more terrible cycle of over-organization and general paralysis. For the cycle of boom and slump there was at least this to be said: each successive boom found the world more prosperous than it had been before: a revolutionary cycle arising from the attempt to enjoy the benefits of brains that did not exist would, on the contrary, make the world progressively poorer in material resources as well as in intelligence. A country can live beyond its material income and then work or starve to pay off its debt: there is no such easy road to recovery from a spell of living beyond one's intellectual income.

Other European Countries

If Britain and the U.S.A. can produce barely enough intelligence to run their complex industrial machine and democratic systems of government, what is the position of countries such as France, Germany and Italy? There are no direct figures which will enable us to answer this question, but some of the experiments carried out in the United States suggest that it is high time some of these countries surveyed their resources.

The tests applied to recruits joining the American Army in 1917 and 1918 showed marked variations according to the country of origin. The results may be expressed by giving the percentage of each group of foreign origin whose score exceeded that of the average native-born white American.

INTELLIGENCE OF FOREIGNERS IN U.S.A.
(Percentage exceeding American average)

Country	%	Country	%	Country	%
England	63	Canada	47	Turkey	25
Scotland	59	Sweden	42	Greece	21
Holland	58	Norway	37	Russia	19
U.S.A.	50	Belgium	35	Italy	14
Germany	49	Austria	28	Poland	12
Denmark	48	Ireland	26		

OTHER EUROPEAN COUNTRIES

Every effort had been made to eliminate differences that might arise from differences in language and education, and since the number of foreign-born Americans who were examined was over 12,000, the results carry considerable weight.[1]

Similar results have been obtained by testing the intelligence of American school-children of foreign parentage. G. Brown, for example, applied the Binet-Stanford tests to 913 American children whose parents had been born in foreign countries.[2]

Country	Medium IQ	Country	Medium IQ
Norway	103	France	95
England	102	Finland	90
Germany	102	Slovakia	86
Sweden	102	Italy	77
Austria	99		

Brown's results were based on too few cases to be conclusive: only thirty-one of his children were of Slovak parentage and only thirty-four Norwegians, and a few more added to the sample might well have made a big difference to the results. Working on a larger scale, however, Berry tested 10,000 children at Detroit and divided them in three groups according to ability.[3] The percentages in the top group were:

Country	%	Country	%
English	29·8	Various Others	16·1
Canadian	29·6	Russian	15·4
U.S.A.	28·7	Polish	9·0
German	25·2	Italian	6·1

The natural embarrassment of the Englishman at finding his countrymen so highly rated by American observers may be tempered by the reflection that perhaps the Englishmen who

[1] C. C. Brigham, *A Study of American Intelligence*. Princeton, 1923.
[2] *Journal of Educational Research*, Vol. V. 1922.
[3] Ibid., Vol. VI, 1922.

emigrate to the States are the brightest of his countrymen whereas Italy, Poland and Slovakia contribute emigrants on some other basis. After all, the social and occupational classes which sent emigrants to the U.S.A. in the years before 1914 varied widely from one country to another, and some part of the differences noted by these observers may have been due to differences in social level rather than differences in nationality. Nevertheless, the differences are striking enough to make one ask very seriously whether Italy or Poland, given equal material resources, could man an industrial system or a mechanized army as effectively as Britain or the U.S.A. One is also left wondering whether they can permanently and effectively adapt the same system of government to their own needs.

Attempts have been made to compare the intellectual attainments of different countries indirectly by working out the number of patents taken out per million inhabitants per year.[1] The method is unsatisfactory because some countries, such as Germany, rejected a high proportion of the applications; others, such as Britain, charged high fees; but it is quite clear that Switzerland, Britain, Germany, France, Belgium and the Scandinavian countries are far more inventive than Italy or Poland. The order of the list would be much the same as that of the countries arranged according to output per worker, or income per head, doctors and nurses per million inhabitants, or even expectation of life. One may therefore argue that the high inventiveness of the Germans, Swiss, French, Belgians and British is the result of a high standard of living rather than great native talent: equally well, one may argue that their high standard of living (which in 1939 was more than double that of Italy, Poland or the U.S.S.R.) came from high intelligence and a capacity for hard work.

One small piece of evidence is available: the productivity of Polish and Italian workers in American factories, though less than that of native-born Americans, is a good deal higher than the productivity of Polish and Italian workers at home. This is

[1] Mark Jefferson, 'The Geographic Distribution of Inventiveness', *Geographical Review*, Vol. XIX, No. 4. October 1929.

to some extent reassuring; but the jobs concerned are those that call only for B or C intelligence, and the crucial question remains: do as many as 10 per cent of all Poles and Italians possess intelligence which could be graded A or A+ by British or American standards?

It would not be a difficult task for the governments concerned to find the answer. One can be fairly sure that they will do no such thing. Political and industrial systems will be worked out by trial and error, and national comparisons will be made by war and economic struggle, which are more painful than a business-like assessment of resources, but are also less humiliating.

The Problems of India, Africa and China

The heavily industrialized societies of western Europe and North America demand not only a high average of intelligence but also a high percentage of men and women of outstanding ability. An industrial society, or an agricultural society with a high production per head, needs intelligence just as it needs coal or oil or water-power. Are the human resources of India, Africa and China sufficient to enable them to achieve the material prosperity of the West?

The question is not an insult: it may well be that the peoples of China, for example, have qualities rare in western Europe and yet lack the special qualities needed if modern industry and mechanized farming are to be carried to the pitch attained in Britain and the U.S.A. After all, the industrial organization of the Western countries is the product of the special temperament and talent of their peoples: it would be surprising if the same pattern of production and government could be imposed on people of a very different heritage.

Poor attainment, however, may be the result of unfavourable surroundings rather than inadequate ability; and it is difficult to devise tests that will give a fair assessment of people totally unaccustomed to the idea of intellectual competition. Even a non-linguistic test, such as fitting wooden pegs of various shapes into appropriate holes, is as foreign to 'primitive' people as it is

familiar to those who are called 'civilized' precisely because testing and juggling with pens and ink and bits of paper play a very large part in their education. In the United States, however, the differences which make it difficult to compare a native African or Indian with a Norwegian or Canadian are reduced to a minimum; and serious attempts have been made to find tests that will give a fair opportunity to all the various racial stocks, whatever their social background.[1] These tests place the whites at the head of the list, followed by the Chinese and Japanese, the American Indians, and then the Negroes. American negro children keep pace with white children up to the age of five or six, then fall behind; and the mental age they ultimately attain is about two years below that of white children attending the same type of school or college. Measured in I.Q., the *average* level of the American negro is about twenty points below the average for American citizens of European stock.

The tests do not prove that the average American or Norwegian is inherently superior to the African or the Chinese *as a person*, but they do show that in the kind of ingenuity required to mend a broken radio-set or to answer an official questionnaire, the Norwegian and the American start with a considerable advantage. Individual negroes may make admirable radio mechanics or highly intelligent civil servants, and even among the most primitive groups there may be individuals whose mental ability (as measured by the tests) is of a very high order; but the total percentage of American negroes belonging to our grades A and A+ is less than a quarter of our standard 10 per cent. There is no reason whatever to believe that the proportion would be higher among the negroes in Africa (there is even some reason to suppose it to be a little lower); but unless that proportion can be radically altered (for example, by selective breeding) a negro state cannot possibly be expected to run an intricate industrial system, and the prospects for negro democracy on the European model are disheartening. It is not simply that more education and greater material resources are needed:

[1] S. L. Pressey and G. F. Teter, *Journal of Applied Psychology*, Vol. III, No. 3. September 1919; and S. M. Derrick, ibid., Vol. IV, No. 4. December 1920.

there may be a real shortage of the basic intellectual material. It is one thing for the European to say, in a somewhat patronizing way, that the Africans (or the Chinese) are very intelligent people; it is quite another thing for a responsible African or Chinese statesman to act on the assumption that 10 per cent of his countrymen belong to our A or A+ category. The countries of Europe and America have a grave responsibility when they saddle a 'new' country with a system of government or of industrial production which they themselves find barely workable.

B.-P.P.M.

Prosperity depends on horse-power per man, and horse-power per man depends on brain-power per man, by which we mean not the *average* I.Q. of the population but the proportion of A and A+ brains available. Such slender evidence as is available tends to show that the figure is something like 10 per cent for all the countries of north-western Europe. It may be a little lower for southern and eastern Europe and for India and China. It is almost certainly lower for the native territories of Africa, and may be as low as 2 or 3 per cent. What it is for the Arab countries, we cannot say.

Even the countries with the highest B.-P.P.M. are suffering from a shortage of the more intelligent workers, and the shortage is likely to become rather more acute if the less able sections of the community continue to breed faster than those of greater ability. In the world as a whole, the same problem has to be faced on a far bigger scale: the races with the highest intelligence are breeding least rapidly.

These facts should at once govern our aspirations and direct our efforts. We need more intelligence, not less, and we need to make the best use of the intelligence that is available. In particular, we need to consider the effect of climate and of general social environment on mental activity. It is a striking fact that the countries which seem to be most intelligent, and are certainly most energetic and prosperous, all enjoy temperate climates, and it is no less striking that in general the birth-rate is lowest in districts in which industry overshadows agriculture.

Over two or three generations, climate certainly has a marked effect on energy and attainment. In physique and energy, Americans of the Canal Zone are well below their forebears in the United States; the 300,000 'Poor Whites' of South Africa are lacking in initiative and self-reliance although the stock was originally as good as any in the world—Dutch, German, French and British. In the Bahamas, where the white population is descended from sturdy Loyalists who came south at the time of the American Revolution, a large portion of the community has degenerated,[1] and the white farmer is scarcely ahead of the average negro. In the flat 'frying-pan' areas of Algeria, the children of the French settlers are pale and lethargic, and infant mortality is even higher than among the Arabs. In the United States, the white farmer of the south is less efficient than negro farmers in the north.

And yet, in spite of this obvious physical degeneration, the original resources are still available; the majority of the poor whites in South Africa, for example, are of normal intelligence. Proper housing, with protection against excessive heat and cold, would almost certainly go far to restore the original energy of these debilitated stocks; and it may well be that the native races themselves, whatever their intellectual endowment, would attain a far higher standard of work if they made the control of climate one of their first objectives. An air-conditioned Senate House may well be the first requisite of self-government.

As for our other problem, the differential birth-rate between the intelligent and the unintelligent, the industrial worker and the farmer, the temperate zones and the tropics, it is a matter which calls for more detailed attention. There are many factors working to reverse the present trend, but the decay of the Incas, the Aztecs and the Mayas, long before they were touched by European power, is a sufficient warning that a social order may be prosperous and enlightened and yet contain within itself the seeds of its own destruction. Perhaps the Mayas declined because their wasteful system of agriculture, and their great ex-

[1] Ellsworth Huntington, *Civilization and Climate*. London, 1915. See also A. G. Price, *White Settlers in the Tropics*. New York, 1939.

pansion of population, gradually drove them down from the cool hill-towns in which their civilization had its birth and reached maturity; perhaps because the priestly ruling caste was overthrown in a popular revolt and no equally competent class emerged from the revolution. We need to look at the malaise of our own society, and ask whether it is likely, as it develops, to lead to still further decay and a still greater loss of intellectual capital, or whether it is the beginning of a real awareness of the need to conserve men as well as metals, brain as well as coal.

CHAPTER VI

HOW MUCH WILL OUR NERVES STAND?

The Modern Man, or Nervous Wreck

Will Cuppy, in his useful book, *How to Tell Your Friends from the Apes*, asserts that there are about 2,000,000,000 Modern Men or too many. There is some confusion of thought here, but nevertheless there is a close connection between over-population and the nervous troubles characteristic of modern civilized life. Wherever a large number of people live together in an area which is not big enough to support them through its own agricultural produce, there you have bad temper, worry, chronic anxiety, insomnia and nervous breakdown.

Our mental health is a vital part of our personal capital: it is a vital part of the world's capital, too, and yet in the cities and in all the areas served by modern transport and communications, we are constantly frittering it away on mere *resistance* to our surroundings. For years, we stand up to the noise and hurry, the stale food, the lack of fresh air and exercise; and then suddenly something cracks, as it cracked one morning in the rush-hour on the down-town platform of the I.R.T. at Grand Central, when the platform guard was 'packing 'em in', clerks, typists, bankers, shopkeepers and all. 'I just couldn't stand it any more,' the banker said in Yorkville Court. 'For four years I've been going through this same thing. I was on the fringe of the crowd and this fellow'—he indicated the guard—'got behind me and began pushing. He pushed and pushed and got me halfway through the door. Then the door started to close on me. It hit me on the shoulder while he was still pushing. I turned round in the crowd and faced him, and I hit him in the face.

Judge, I know I done wrong, but I've been taking this packing into subway trains like a sardine in a can for four years, and it finally got me down.'[1]

The occupational diseases of the manual worker are well-known—the silicosis of the miner, the anthrax of the wool-sorter, the paralysis and anaemia of the lead worker. Mining and seafaring, quarrying and scavenging, each of these has its special hazards and levies a tragic toll on our human capital; but the typical diseases and illnesses of city life are peculiar in that they do not spring directly from the nature of the victims' occupations but from sheer density of population. And while we apply more and more preventive measures to industrial hazards we do nothing about the more serious hazards of propinquity. The nagging jangle of someone else's telephone, the roll and clatter of trains, the brainless blather of the radio from an empty room, the motor horn that wakes us so briefly that only our worn nerves know that we haven't slept continuously and deeply,[2] all these spring from proximity. Even eyestrain, so often the unsuspected cause of nerviness and permanent fatigue, is largely the result of our attempt to organize ever-increasing numbers, where lesser numbers could live without that organization. Then the tempo of our lives, too, is in the last resort the result of a desperate effort to keep more people alive than our world will comfortably hold. We save time (time which might have been spent in the healthy exercise of walking, or in a long peaceful journey cut off from all communication) by trains and taxis, aeroplanes and buses; and spend interminable minutes in a traffic jam or tedious, maddening hours at an airport waiting for some announcement of the postponed flight.

What is it all worth? To what extent does the existence of the additional millions compensate for the loss in quality in the lives of the city dweller and the industrial worker? How can we

[1] *New York Times*, 11 January 1940.

[2] A character in a story in *The New Yorker* (2nd April 1949) speaks of sleep as 'the first great natural resource to be exhausted by modern man. The erosion of the nerves, not to be halted by any reclamation project, private or public.'—*J.R.*

measure the obvious gain in material wealth and comfort against the emotional poverty and physical discomfort? The advertiser tells us promptly enough how many man-hours are saved by flying to Manchester or Seattle: it is not his business to point out that the noise of his plane is an abominable nuisance to Oxford, or that the time saved had better be devoted to a quiet holiday if the hustling business man isn't to turn himself into an irritable, anxious father or a cold, preoccupied husband. We have made it possible for the individual, as for the race, to rush from crisis to crisis, without a decent and pedestrian interval between; and with each new device we count only the advantages and leave our harassed nervous system to bear the disadvantages. And yet, some arithmetic of this kind is necessary. We need to decide what kind of life we want before we decide the number of telephones and people; for the three things—the size of the world's population, the material standard of living, and the quality of the individual life—are bound up together; and unless we take thought, a gain for one may well mean a loss for the others.

The Grand Ecology

The balance of forces in nature is so complex that we can never be quite certain, until the experiment has been tried, that a minute change at one point will not produce prodigious and devastating effects throughout the world. The slow advance and retreat of the polar ice-cap, the rising and sinking of continents, the evolution and decay of the great primeval dinosaurs, all these have in their time slowly changed the face of the world; but in the past three hundred years there have been great and unforeseen changes springing from relatively small causes. Farmers, trained in the European tradition, have ploughed up the Great Plains of North America, and the plains have crumbled into dust. Goods travel from Africa to Brazil, from Australia to San Francisco, carrying germs and insects from regions which had long since adjusted themselves to their ravages into others that have no defences ready. Man exterminates one kind of pest which has robbed his orchards or his barns from the beginning

of history, and finds that some other pest, long kept in check by the first, now flourishes and cannot be destroyed until the old pest is re-introduced. He discovers how food can be preserved in tins, how giant crops can be grown on a small area, how almost any oil can be turned into margarine—and then begins a frantic search for the vitamins or whatever else may be lacking from his new diet. At his ports and airfields, he stands on guard against cholera and sleeping-sickness, the Colorado beetle and the Indian meal moth. In his laboratories, he feeds rats on his own civilized diet and finds that they become sterile or turn to cannibalism. At his agricultural research stations, he seeks desperately for the cause of the new diseases which afflict the prize turnips and giant potatoes grown in soil enriched with phosphates and other useful chemicals.

The more he monkeys about with nature, the more necessary it becomes to monkey about still more; and the new problem is often in a field far remote from the old, for the process of innovation is irreversible. From 1900 to 1945, three-quarters of a million people were killed in automobile accidents in the United States, which is exactly double the number of American troops killed in the wars of 1914–18 and 1939–45: it is the legislator, the traffic-cop, the teacher and the civil engineer who are left to cope with the problems that the manufacturer and the automobile engineer have created. At the far end of the scale, and possibly entering the domain of comedy, there is the suspicion that hot baths may cause sterility in the human male and that people brought up on pasteurized milk may be free from reproductive power as well as from tuberculosis.

It is not merely that each problem solved creates new problems: sometimes the solutions themselves are provisional and precarious. The great irrigation dams (which incidentally stop the fish from mounting the rivers) themselves begin to silt up; and in some cases, where calculations have been at fault, they silt up rapidly. In the world of micro-organisms, man's achievements are still more precarious and constant vigilance is necessary. The germs of disease sometimes change their character and acquire a new resistance; a mould such as penicillin, with its

almost miraculous properties, may not breed true indefinitely. And yet, with each new discovery and achievement, we build up our civilization with the brave confidence of villagers returning to the shadow of the volcano after an eruption. More and more the scientist becomes vital to our civilization, even if we are only to maintain the *status quo*; and not only the scientist, but also the policeman, the customs officer and the legislator. We have made it possible for the world to become a single ecological unit, and we ourselves are desperately striving, through regulation, inspection and regimentation, to save ourselves from the forces we have released.

Regimentation as the Price of Order

One result of the great increase in the world's population is the unprecedented need for planning and discipline. If the resources of a family, or a nation or a whole world, are only just equal to their needs, it becomes important to know exactly *what* is going to be needed where and when. A world living up to the very margin of its income, and yet regarding itself as a unit, must needs plan in detail the movement of its citizens, and the disposal of its stocks. Liberty to make what one likes, to travel as one likes, to buy what one likes, is necessarily curtailed. Only a unit content to live at something less than its maximum standard, or continually expanding its wealth or frontiers, and having a 'Devil-take-the-hindmost' attitude to other groups and to its own weaker members, can afford 'liberty' in the widest sense.

If we are to ensure that everyone has the highest material standard of living that is compatible with our resources, and that every area supports its maximum population, we must ensure that there is no waste of labour, material or land; we must direct labour, ration consumption, and regulate the cultivation of land. The devious routes by which humanity pursues its long fool's errand to the grave must be restricted and co-ordinated. The carefree tramp, the impoverished poet, and the landowner with a passion for Italian gardens, are enemies to be fought as ruthlessly as the copra beetle or the meal moth. Even those expensive but popular parasites, the dance-band leader and the

film star, must justify their existence by the extent to which they increase the productivity of their fellow citizens.

Long before social arithmetic reaches this point of refinement, the effects of regimentation become apparent. The housewife whose daily bill-of-fare is determined by the Ministry of Food, the miner who is told by the Ministry of Labour that he cannot change his job, the manufacturer who is driven to employ three clerks to fill in Board of Trade returns, the factory worker who is firmly told that he must take his holiday in March, each feels frustrated and annoyed. It is quite true that poverty always did impose restrictions on the vast majority of mankind, and still does; but the restrictions which follow from general shortage and national or international planning are superimposed on the others (or appear to be) and are different in kind. Almost invariably they compel the individual to take decisions in advance or to accept decisions that have been made for him. In the Australian desert, you can drive a motor-car where you like and you must fight the natural hazards as best you can: in London or New York you must stick to the Rule of the Road, obey the traffic-signals, keep within the speed limit, and take care not to park your car in a Prohibited Area. Instead of doing your damnedest to get through alive, you must rein yourself in and accept the regulations which alone make possible an agglomeration of five or eight millions; and this restraint wears down the nerves and gives no sense of triumph in the end. You have endured the usual frustrations with only the usual wear and tear: you have overcome no great difficulties on which you could look back with pleasure and elation.

Order is inseparable from crowded life, and in a larger way, regimentation is essential if we are to have a crowded world which is not simply a pullulating mass of misery and confusion; but how much will this order and regimentation cost in terms of frustration and bad temper? The motives which induce the citizen to go on doing his share of the world's work are complex and diverse; the little things that give him satisfaction and make him feel that all else was worth while are not easily defined, but the sense of achievement and the belief that, to some extent, he

is master of his own destiny, are certainly among them. The apathy which attacks the unemployed or the too-rigorously employed is like the apathy which wears down a party of conscripts stationed for no very obvious purpose in some out-of-the-way corner. It is not merely the result of boredom: it is a natural protection against a more serious nervous breakdown. If no action of ours can affect any of our aspirations, we must either abandon all aspirations or go mad.

Plainly, we are dealing with extreme cases; in ordinary life what one must expect is a mild loss of enthusiasm and initiative, an increase in bad temper and petty bullying, a damping-down of all generous emotion, and an increase in political cynicism. The conditions of conscript life are tolerable enough when they serve some large over-riding purpose acceptable to all. Will they be tolerable when the purpose is merely the accommodation of another two hundred million conscripts in an overcrowded world?

There are no figures and no general observations which will help us to give an answer. That nervous diseases have increased in civilized countries and are still increasing is obvious; but whether the increase in nervous strain and its counterpart, apathy, outweighs the increase in population is a question no one could answer even if figures were available. It is a question which concerns the quality of life, and quality cannot be weighed against quantity. In the long run, the question will be answered by history; perhaps in a few centuries time, the enterprising, the sensitive and the ambitious will have died out, leaving a race of listless automatons. Or perhaps it will be the apathetic and inert who will die. But for the present, it is our generation which is deciding whether the question is to be posed in this way. After all, the decision in favour of a crowded world, where every scrap of food must be rationed, every hour of work or leisure tabulated, every movement foreseen and every free impulse inhibited, has not yet been taken as a deliberate, fully-conscious decision. It is merely that the world is behaving as if the decision had been taken. Human nature demands a little liberty, a little of the unpredictable, and a little irresponsibility, just as it de-

mands sleep and relaxation; and this demand means that maximum efficiency will always be attained with something less than perfect organization.

It is true that man is in part a social animal. In some primitive races, the individual appears to be more conscious of the needs and aims of his group than of his own needs and aims as an individual. He is a cell in the body politic, and wrenched out of the body politic he will wilt and die. The actions and gestures that are his contribution to the life of the community are his only mode of being.

The strength and weakness of civilized man is that he is neither wholly social nor wholly individual. His community is living and not static because he himself is independent and resourceful. The very conception of intelligence which we have used in comparing civilized man with his more backward and less progressive neighbours is itself a measure of adaptability; and this adaptability becomes a burden and a handicap when man finds himself in a world that calls for rigid and universal organization. The average man cannot bear very much loneliness and independence; neither can he long endure intense crowding and ant-like regimentation. Just as the industrial psychologist tries to calculate (or to find out by observation and active sympathy) just how much monotony, how much distraction, how much idle gossip, the factory worker needs if he is to do his best work, so the statesman will have to widen and humanize his conception of efficient social organization if he is not to find his efforts stultified by a nation grown listless or neurotic through over-discipline and over-stimulus.

Mere conservatism is not enough, just as a free-and-easy atmosphere is not enough in a large factory. We need to measure the incidence of anxiety and nervous strain and calculate its cost as we calculate the working hours lost through the common cold. We need to decide the optimum density of population for particular trades and types of people on some other basis than that on which we calculate the size of a decent pigsty. We need to weigh the knowledge gained through detailed statistical returns against the cost in time and temper and general loyalty.

Above all, we need to restore the idea of *quality* to our political arithmetic. The human being is not merely an animal, and to count his needs merely in terms of food and creature comforts is to starve his spirit. It simply is not true that a world of four thousand million people is necessarily better than a world of half that number even if the four thousand million are well fed, well clothed and housed, and provided with a wealth of gadgets they have been trained to need and make. The bigger, wealthier world may be the more irritable and the more resentful, and each new addition to their wealth may add to their dual burden of responsibility and boredom.

The Burden of Responsibility

All social life calls for restraint, and crowded social life intensifies that demand; our tempers, like our dogs and radio-sets, must be kept under strict control if we are not to suffer the displeasure of our neighbours. But more than this, civilized life, whether in town or country, imposes an immense burden of responsibility. Our industrial and commercial systems, our communications and all our public services are all extremely vulnerable to dishonesty, clumsiness, sabotage and mere tomfoolery. The British Post Office system would cease to work if the vast majority of people did not refrain from defrauding the Savings Bank department, playing the fool with the telephone, putting fireworks in the letter-boxes and posting unstamped letters to their favourite enemies.

To most people, these temptations are not strong, but to a minority the sense of power makes an irresistible appeal, and most of us are conscious of having been tempted at some time or other to such a display of irresponsibility. To a lunatic, or to a minority with a flaming grievance, the vulnerability of our complex system is a godsend. Such people can attract attention, or revenge themselves on the community, or bully the community to give them what they want, by poisoning a town's water supply, by cutting electric cables or telephone wires, or by flinging a literal spanner in the works. In normal times we may brush aside the temptation as easily as we resist, in normal

health, an impulse to throw ourselves off a cliff; at times when we think we are neglected or illtreated or undervalued, a far greater effort is needed; and it is remarkable how seldom strikers and political minorities have up to the present resorted to major sabotage.

The conscientiousness of civilized man springs from something more than the fear of losing his job. In many walks of life, dishonest workmanship could pass undetected for a long period, and in some cases it would not be traced back to the individual worker at all. And yet, in spite of all the opportunities to defraud the community, the general standard of honesty and responsibility remains—as it must remain if half the community is not to be employed as policemen. Only in limited fields are there serious failures: railways, nationalized or unnationalized, are regarded as fair game by a small section of the community, and though the passing of the old cut-throat razor has diminished the losses of those admirable leather window-straps, ticket frauds are still fairly common and widely distributed. Losses of beer-glasses from public houses and books from public libraries, on the other hand, are small enough to make one feel that the ordinary citizen either takes an affectionate and proprietary interest in his pub and his library, or else nerves himself to the standard of social conduct demanded by these amenities.

The daily life of tens of thousands of postmen, policemen, engineers, bus-drivers and mechanics shows a devotion to duty which is something more than a matter of immediate self-interest; and the ordinary citizen, too, shows even as he walks down the street, a sense of responsibility to his fellows. In time of danger or shortage, the demands may be high. An official poster displayed in Britain in 1948 showed a small child climbing on a chair to reach the electric light switch: "Mummy forgot to turn it off," she is saying. Civilized children have to show a good deal of restraint at the best of times—not for them the wild hours of truanting of my childhood, riding stolen donkeys madly across the New Forest—and here they are being asked to show a positive and vigilant sense of responsibility to help the country out of its economic difficulty. No wonder that from time

to time someone breaks down under the strain. All England was delighted in 1947 when a man stole a London bus and drove it round and round Hyde Park 'for fun'.

How far the decay of private moral standards in wartime is due to the increased demands on communal loyalty, it is difficult to say: after all, the impulse to beget children no matter how or where when human life is cheap and precarious, is old and deeply rooted. But it is obvious enough that in all countries there has been a decay in personal honesty and civil responsibility as a result of prolonged rationing and restriction, and that in some countries the public standard of honesty has simply not been able to bear the strain. Honesty and the sense of responsibility are vital to any country with a complicated industrial, commercial and governmental system, and governments should be very chary of straining their citizens too far. The danger is not merely that new regulations may be flouted, but that older and more necessary codes of conduct may also lose their compelling force. A government that demands too much of its citizens will sooner or later find itself receiving too little.

Of course, the burden may be lightened by removing some kinds of responsibility altogether. On a short view, there is no reason why the ordinary British citizen should take the trouble to try to form a sound judgment on the intricacies of Greek politics or the aspirations of the depressed classes in Nicaragua. The responsibilities of a democratic citizen are a thundering nuisance to the democratic citizen, to his elected representatives and to everybody else. If food and other necessities of life become scarce through the over-population of the world, and if we still try to achieve a just distribution through controls and rationing, those controls may impose such a strain on the ordinary citizen's sense of responsibility that he may become only too willing to give up political responsibilities which are already irksome: 'Pre-war, now, I've bought a sixteen-page newspaper and no bloody news at all. Those were the days.'[1] The danger of dictatorship comes not so much from the ambitions of the

[1] Character in *Charade* by John Mortimer. London, 1948.

would-be dictator as from the growing apathy of a wearied and overstrained nation.

Parliamentary democracy demands a high standard of intelligence, knowledge and social responsibility from everybody. A fair knowledge of geography, some understanding of economics and sound judgment of character are necessary as well as public spirit: politically, the British electorate is as competent as any in the world; and yet even in Britain democracy only just works and the British public refuses to recognize the facts of an unpleasant situation until zero-hour has struck. To prolong existing strains unnecessarily, or to add new burdens, is to bring us nearer to the point at which a breakdown becomes inevitable. In the near future, if we wish to retain parliamentary government (and no other form of government offers the same scope and dignity to the ordinary citizen) it will be necessary to calculate with rueful care the exact amount of damage that will be done by each new restriction, each new demand in public spirit, that arises from the disequilibrium between the world's population and its agricultural produce. It will be necessary to calculate all the more carefully, and with no wanton optimism, if the quality of the world's population is allowed to decline whilst its quantity is disastrously increasing.

The Burden of Security

The type of civilization appropriate to a crowded world not only introduces new hazards and tiresome responsibilities into our lives, but also new kinds of boredom. The hazards are mostly of a kind such that as individuals we can do little about them: the danger involved in air travel, the chance of death by bombing, the impact of conscription and worldwide economic troubles on our private lives, are all risks to be endured passively: they do not (except at the rare moments when the bombs are actually falling) relieve the tedium of an all-too-tidy life.

That tedium had been rendered all the more acute by our own struggles after security. Efficient police forces deprive us of the excitement of meeting drunks and footpads; trade unions look after the steadiness of our wages; governments sworn to a

policy of full employment do their best to secure the permanence of our jobs; insurance schemes, whether national or private, iron out the humps and hollows of our passage through life. In North America and western Europe, the prospects of attaining great power and wealth is much dimmer than it was fifty years ago, but the risk of utter destitution is also far less. If we succeed in building up a useful little nest-egg from our savings, our government does its best to prevent us from backing a risky and adventurous industrial enterprise, and appeals to us to invest our savings in the tame and respectable security of gilt-edged stock. Apart from the impact of world affairs, we have far less to worry about (and far less to hope for) than our father and grandfathers.

The first effect of this new security has been an active search for substitutes for the good old-fashioned kinds of excitement and risk. The risk of war or of world-wide hunger does not meet the need, for it is not a risk we can do anything about. We want a game in which we can secure successes as individuals, and by our own nimbleness or judgment. The desire for safety and security is deep and genuine; so is the desire for excitement and adventure: and the two are not necessarily contradictory. We want the chance of big rewards without the risk of total ruin. The answer, for millions of our contemporaries, is the football pool or an evening's dog-racing.

It is useless to inveigh against the growth of gambling unless we face the fact that petty gambling meets a need deeply rooted in human nature and in the economic structure we are building. Every increase in security will lead to an increase in gambling until we find some new and better form of excitement or outgrow the impulses and cravings which saw our ancestors through many centuries of hazard and uncertainty. It is conceivable that in the course of generations, we may develop a kind of collective mentality that will accept and relish collective risks and aspirations as substitutes for individual adventure; but for the present we must recognize that to the individual who has a small and fairly secure margin above subsistence level, but very little chance of gaining power and wealth through his own

efforts, the temptation to try to attain wealth and power through gambling will be far greater than it was for his ancestors. And for every dozen who gamble with their margin of comfort, there will be one or two who gamble well beyond that margin.

Gambling with money, or with relief tickets, or with petrol coupons, is not however the only outlet for the civilized man who finds his life organized without regard to the complexities of his own nature. It is the city-dweller rather than the countryman who feels the burden of security and monotony most heavily. The promise of the first primrose, the threat of a dry summer or a wet harvest, the prospect of a snowy winter, play relatively little part in his life, and he lacks any contact with that large harmony of nature which can be a pattern for the harmony of the individual life and can modify the need for excitement and distraction. The city-dweller's life, in spite of the risks arising from road accidents, is at once dull and pointless. Motor-cycle racing offers a distraction and an agreeable physical risk to a small minority; the fortunes of a particular football and cricket team are a substitute for a co-ordinating aim in life.[1] Many thousands of the young men and women who go walking or cycling or camping in the country build their lives around their holidays and week-ends. *There*, they feel, is something significant, something consoling and sustaining, something that involves physical risks and hardships and uses all their faculties, not merely their ability to thump a typewriter or keep a watchful eye on a machine.

There is a good deal to be said for the view that the development of mountaineering was the other side of the penny to the Industrial Revolution. Its first adherents belonged to the professional classes of the big cities: they were by origin landed gentry divorced from the countryside. The climber always protests that his sport is not dangerous, and that he is as safe on the summit ridge of the Zinal Rothorn or the Zmutt Arête of the Matterhorn as in Regent Street or Fifth Avenue, but he would

[1] 'The country needs rain,' I said to a barber in May 1948. 'Yes, get Surrey out,' came the answer, with a knowing grin.

not deny that the essence of mountaineering is to accept natural hazards and then circumvent them. He finds the sport satisfying because success or failure in it depend on his own judgment, skill and endurance, and because it engrosses all his attention: the complexities of industrial life are irrelevant, and the climber has neither the time nor the energy to think of them. He is fighting more primitive battles, and thereby resting from the vastly more complex struggle of ordinary existence.

Sailing offers something of the same type of satisfaction: it may be hazardous and it is often exhausting; but the hazards are exhilarating, and the deep exhaustion is the physical exhaustion which is a relief to the intellectual worker and the skilled craftsman who earn their living through constant anxiety, not physical effort. Hills and the sea are primitive and obdurate: one can come to terms with them; one cannot conquer them. In the end, one learns to accept their moods, to judge the possibilities, and to work within a harmony beyond our power to control. No one can long continue sailing or climbing unless he comes to see himself as a part of the forces of nature; and perhaps the deep satisfaction which some people find in these sports owes most of all to this restoration of a sense of unity with nature which is lacking in the day-to-day conditions of city life.

In a more indirect and intellectual way, the arts, too, can offer adventure, exhilaration, and a sense of unity and purpose. A passion for Mozart can redeem the life of the filing-clerk, the collection of early colour-prints brings excitement and uncertainty into the life of the pensionable civil servant. The poetry of Wordsworth or Rilke throws open a window on a world beyond that of the daily journey to the office or the factory, and reveals objectives for the sense of power other than the domination of one's fellow men and the maltreatment of the world's resources. But these are only palliatives, just as mountaineering and sailing are only limited and partial escapes. They are good in themselves, but although they render daily life tolerable they do not alter it. The fundamental discord remains; and, what is more, these resources are only open to a relatively small part of

the population. For the semi-literate, the tone-deaf, the emotionally insensitive, the only escape is into the fantasy world of the cinema. It is in the cinema that millions of people in North America and western Europe find their emotional and intellectual daily bread. Whether that daily bread contains the appropriate vitamins is a question which only time will answer. Too often it seems to be a mass of mere emotional carbohydrate which offers relief from a real hunger, but no real nourishment. Because people are dissatisfied with their lives, they are being turned into cruder, duller creatures than they need be. But for the moment, and up to a point, the cinema does its job: it renders endurable a life which is intrinsically unsatisfactory.

War as Relaxation

For those whose impulse toward adventure is not satisfied by gambling, or by week-ends in the country, or by some sport with an element of risk, there is one outlet remaining. For many people, war is at once a rest from responsibility and a change from the tedium of civilized life. The major problems confronting humanity can be forgotten in a more immediate and simple struggle, talents unused or severely repressed in ordinary civilian life find an outlet and appreciation. In some ways, war suits human nature better than our constricted and worrying peacetime existence. No decent civilized man will admit that he wants war; and on balance, adding together all his conscious and semi-conscious wishes, he does not want war. But so long as peaceful existence is not fully satisfying, so long as millions of people find both their work and their play a little pointless, so long as they feel that their lives are unduly narrow, they will always find when the worst has happened that the worst has its compensations. And when peace comes, they will discover that their old problems have been evaded, not solved, and that the irritating restrictions and discipline of the pre-war period are ten times worse when the world has enjoyed a spell of reckless destruction.

In three ways an overpopulated world is impelled toward war: shortage of supplies intensifies selfishness; the rattle and frustration of highly-organized industrial life sharpens and shor-

tens tempers; the boredom and monotony of that same type of life lower our resistance to any course of action which seems to offer excitement and opportunity. These are the three factors which the people of the world, acting through their governments, must direct and modify if they want to avoid war. We must see that there is enough to eat (or that there are not too many people), we must regard our own nervous systems as part of the human estate and treat them decently, we must pay heed to the quality of the hobbies and distractions which compensate us for unavoidable shortages, restrictions and strains. There is little sign that any of these things will be done on a sufficiently large scale; and if the measures are inadequate then any relatively small occasion of quarrel may be the crack through which volcanic forces will emerge.

CHAPTER VII

THE STRUGGLE FOR POWER

Occasions of Quarrel

Man does not fight for bread alone, and a sufficient ration of bread or even an ample supply of all material goods is no guarantee that men will not struggle for power or try to ensure that their race, their outlook and their standards will prevail. The fear of hunger may be a cause of war, hunger itself is not. A country which is over-populated and underfed, and lacks the capital to develop its own resources, will seldom attack a more prosperous neighbour. Proficiency in war depends on the margin above subsistence: the measure of a nation's strength is the surplus of its national income over the bare minimum needed to maintain life on such austere standards as its people can be persuaded to endure for the cause at issue. It is conceivable in a disastrous state of international trade, that a hungry nation might still have a surplus of coal and steel and petrol above its minimum requirements; but even then, that nation would not fight until it had a reserve of food sufficient to see it through a brisk campaign. The world rarely fights when crops are bad, but when crops are phenomenally good. The average annual production of wheat in the years from 1906 to 1910 had been 3,410 million bushels; in 1912, the world's wheat crop broke all previous records and reached 3,840 million bushels; in 1913, the crop (4,070 million bushels) again broke all previous records. The 'carry over' stocks of old wheat were the largest ever known. Even so, war did not break out until it was clear that the harvests of Germany, France and Russia were again above the average. Similarly, 1937 and 1938 were years

in which the world again produced unprecedented wheat crops —5,800 million bushels in 1937 and 6,575 million bushels in 1938 compared with an average of under 4,700 million in the previous five years. The harvest of 1939 (6,200 million) was again far above the average. In 1939, the world's stock of old wheat (in all the major exporting countries) reached the figure of 768 million bushels which had only been surpassed in 1933, with 787 million bushels. One is tempted to prophesy that there will be no world-wide war until three great seasons again bring the nations up to fighting form and give them that reserve without which they dare not fight.

Nations do not begin to fight when they are hungry, but when their granaries are full. The fear that one day those granaries may be empty may be a factor in driving a nation to war, the fear of being ruled by an alien people may be another, the altruistic desire to make an end of obvious cruelty and injustice may be a third; but beyond all these we must take account of the desire for power, the wish to have one's own way, to lay down the law for the whole world. The desire for power is not intrinsically bad, and it is as strong in most militant pacifists as it is in any chauvinist. Power, the ability to adapt our environment to our own needs, is vital to the human being as to any other animal: it is identical with the will to live, to renounce power is to renounce life. Whether the desire for power operates for good or evil in a particular case depends on what we are asking the rest of the world to tolerate, and on the means which we are using to enforce that toleration. The means may vary from the atomic bomb to Mahatma Gandhi's moral bullying, the end may be anything from the payment of tribute to the imposition of some particular religious or political ritual.

Quarrels within a society, like quarrels between nations, seldom reach their most acute phase in times of scarcity or famine. Bread riots may arise from desperation, but more often the energy which a community devotes to its ordinary political quarrels is directly proportional to its margin above its ordinary level of subsistence. A fair measure of prosperity, with a hint of insecurity or of national frustration, is the most common back-

ground of strenuous political warfare; people who are hungry for power may choose a moment of economic crisis for action, but they can sway listless, hungry masses only if they have built up a strong and bellicose faction in the years of prosperity.

The Lines of Cleavage

To the political agitator, all societies offer a number of permanent lines of cleavage. The young versus the old, the reckless against the cautious, the rich versus the poor, and the social misfit against the happy and contented, these are familiar lines of division, and any competent politician knows how to use them. The divisions between men and women, the married and the unmarried, the skilled and the unskilled, are equally useful, though perhaps less often exploited. Again, any of the major psychological classifications, as introvert and extrovert or the hysterical and the stable-minded, can be pressed into service by the power-hungry agitator.

In no conceivable society can all of these lines of cleavage be eliminated: the divisions are permanent, and it is the new party, or the party in opposition, which will gain most from exploiting them. A responsible government almost invariably wants a united and stable nation: an opposition party must divide the nation before it can begin to rule, and it can rely on many of the young, the unhappy and the unsuccessful to support it anyway. Often, in modern society, it can rely on a fair number of scientists and their followers, for subjects such as physics and chemistry are so much simpler than the art of government, and yet so successful in their own field, that the physicist and the chemist is nearly always certain that he could rule the country better than the government of the day: an occasional word of flattery from the opposition spokesman is all that is needed. Again, any minority which is itself eager for more power, or is afraid of losing its existing power, will always turn towards a political group which is prepared to treat it with unusual deference; and this political group is more likely to be the opposition than the governing party, for an opposition can afford to make larger promises than the government of the day. There is thus

a permanent opposition, actual or potential, in society; but this permanent opposition is heterogeneous, and although it may carry a party into power, some of its constituents then desert and go over to the opposition or join a newer party with larger promises. There is always a delicate moment in the career of a growing political party when it must risk losing some of its old and fervent supporters in order to gain the allegiance of those who like stability, a quiet life, and the devil they know; and this moment must be found *before* the irreconcilables desert.

A skilful political manager will bear these delicate problems in mind, and he will remember that the lines of cleavage cut across one another in the most complicated way. His first problem is to decide the best issue on which to appeal to a middle-aged unsuccessful milkman with three children, a Baptist upbringing, a tendency towards introspection, a dislike of dog racing and foreigners and a firm belief in foreign missions. He must then estimate the number of such milkmen and the percentage which his chosen policy will attract. Finally, when he has decided just what emphasis to give each part of his programme in different parts of the country, and among different classes of society, he must add up his gains and losses. The profession is vastly more interesting and difficult than that of the analytical chemist or racing tipster, and like meteorology it is still in its infancy.

Of course, a well-conceived political programme will always idealize or mask the divisions which are being used. No politician will announce that his is the party of greed, stupidity and violence: he will say that he stands for enterprise, realism and energy, or for a policy which is firm but cautious, idealistic but practical. If a policy is designed to appeal to the timid, it is a good thing to call it wise and patient, and to say that it represents long-sighted courage. A policy which is based on ignorant recklessness is best called modern and scientific; a policy aimed at the exploitation of the poor is called national retrenchment, the robbery of the rich is called social justice. Above all, in a country such as Britain or the United States, a political leader must be sufficiently naive to be deluded by his own terminology

without losing his skill in exploiting the great and enduring social and psychological divisions.

All this may sound cynical, but in fact it is only the other side of a familiar tapestry. Every political party exaggerates some virtues at the expense of others; and we only need to shift our point of view a little to remind ourselves that the virtues it is neglecting or depreciating are none the less valuable and enduring. Almost every political leader is sincere in his devotion to the explicit aims of his party, at any rate while he is actually speaking; but it is not his sincerity which makes him a successful leader, but his deep and often unconscious political sense (or the less deep but more conscious political sense of his electoral agents), and this 'political sense', conscious or unconscious, is largely a matter of playing on the divisions we have already described. The political leader has a vested interest in dividing society, in magnifying grievances, in probing wounds and in exacerbating sores; and it is when he is trying to achieve 'national unity' in support of his party that he is most likely to disturb the peace of the world, for the only ready-made line of division which he can then exploit is that which marks off his own countrymen from others. Given the tinder always present, and given a number of able men eager for power, the alternative to domestic squabbling is war.

The appetite for power is strong, and if it does not find an outlet in art or industry or science, it will seek an outlet in politics. It might be possible so to direct society that few people would develop the burning hunger of a Trotsky or a Roosevelt, a Hitler or a Churchill, a Franco, Bevan or de Gaulle; but until that is done, some people whose talents do not get them on in our existing orderly society will always seek for scope and fulfilment in war or crisis or civil commotion or political agitation. We cannot expect total peace, and just as external war may be the price of a temperary national unity, so fierce political activity may be an effective mask and balm for the inner conflict and frustration of the individual. A society in which people are radically unhappy and ill at ease with their environment *needs* politics to hide the individual heartache; and given politics,

sooner or later it will need war to rid itself of politics. The pathetic thing is that political quarrels are so often unreal and unrelated to the needs of the time.

The Time-lag in Politics

By and large, the ultimate forces that influence policy in an oligarchic state such as Fascist Italy or Communist Russia are much the same as in a democracy. No democracy is ever complete, and no dictatorship is ever absolute. In the first, the government must follow close behind public opinion; in the second the government must drag public opinion on a fairly short rope or run the risk of revolution: the broad lines of a country's policy are determined by the factors of economic geography, but its type of government may determine the speed and energy with which national policy is pursued. Apart from the obvious and familiar difference between a democracy and an oligarchy there are two which have a direct bearing on our use of the world's resources of talent and material. Firstly, the field of manœuvre is much smaller in an oligarchy than in a democracy: only a small inner group needs to be mustered in deliberate and immediate support of a given policy, and the rest can then be bludgeoned by the law or bulldozed by propaganda. Secondly, some of the major social and psychological groups in the nation at large may be completely unrepresented in the relatively small ruling party: the government thus acquires an intensity of character, a decisiveness and tenacity of purpose, impossible in a country in which the electioneering agent is always the skeleton in the Cabinet.

The two points of difference combine to give the oligarchic state one immense advantage: it can ruthlessly discard dead issues and it can cast into oblivion doctrines which have outlived their usefulness. The democratic politician is forever burdened with the corpse of his grandfather. Most people form their opinions in their youth and hold to them as if they were vital parts of their personality. They cannot abandon them without abandoning their own self-confidence and self-respect, indeed they often *have* no character, no decisive personality, apart from

their bundle of opinions. In consequence, it takes at least a generation to achieve a major change in outlook. The original thinker has to convince the journalists and the writers of secondary books; the journalists and writers have to convince the teachers; the teachers convince a new generation of children. The process is slow and salutary; and many a bright idea dies of inanition before it reaches the stage of emerging from the mouths of babes and sucklings as natural and inevitable truth, and therefore a useful slogan for the politician. It is not that the authors and journalists, teachers and university lecturers, are constantly engaged in preaching: often they do not begin to convert their audience until their major premiss has become a presupposition which is never explicitly mentioned in progressive circles. A democratic society is forever trying to solve the problems of to-day with the intellectual and emotional equipment of thirty, forty or sixty years ago. In an oligarchy, the man who can see the problems of the day in their appropriate terms, either gains the ear of the dictator directly or finds himself in Dachau or Siberia; there is no question of a time-lag.

The attitude of the trades-unionist is a case in point: the growth of the trade-union spirit, with its determination to resist the boss, to exact the maximum profit from the sale of labour, and to ignore the indifference or disapproval of the general public, persists long after an industry has ceased to be in private hands. The British mines may be owned by the nation and managed by a National Coal Board; the miner's attitude to the 'owner' is likely to remain unchanged for a generation, just as the southern Irishman, a quarter of a century after 1921, still regards the British Government as the Devil's regency on earth. Whether nationalization will produce a community of contented and loyal miners who will regard themselves as part of a larger community is not a question that can be answered in five or ten years. As long as the old reflexes remain, politicians will cultivate them and exploit them.

Perhaps the greatest problem of the time-lag for Britain arises from the attitude of the working classes to capitalism and the national economy. The great advances of the nineteenth cen-

tury were made possible because a large percentage of the rewards of industry went into the pockets of the capitalists, who in turn re-invested a large part of their profits. The result, on the one hand, was a rapid increase in the real wealth of the country, measured in factories and equipment; and on the other hand, great poverty among the working classes. The movement in favour of a more equal distribution of wealth was a natural reaction, and it gained its objective first through the pressure of the trades unions and then through the action of the government. The result was, on the one hand, less poverty, and on the other hand, less saving. The rate of increase of the country's real resources declined, for the poorer classes, naturally enough, do not save as big a proportion of their income as the rich, and therefore fewer factories and power stations are built, and less mines and factories re-equipped. If Britain is to regain her prosperity, there must be more saving, and if the distribution of profits is such that there is unlikely to be enough voluntary saving, then the saving must be compulsory. In a country in which the need for individual thrift is minimized through compulsory and universal insurance, and in which saving is regarded as an immoral habit of the *rentier*, all new capital must be provided by taxation. To a large extent, Britain's industrial health depends on the speed with which saving, in one form or another, can be re-established as a national policy: an outlook which was appropriate enough in the struggle for a more equal distribution of wealth becomes ruinous when a more equal distribution is in process of being achieved. Fifty years ago, the rising socialists could afford to ignore the useful functions served by the rich; when the rich are no longer rich enough or strong enough to fulfil those functions and are offered no encouragement to do so, the same functions must nevertheless be served in some other way. The crucial question is whether the country as a whole will support those political leaders who recognize these elementary facts, or whether the persistence of an out-of-date attitude will lead them to vote for cake to-day and nothing at all to-morrow rather than bread to-day and cake to-morrow.

Again, there is a similar time-lag in relation to Dominion and

Colonial responsibilities. The attitude which condemned the robbery and exploitation of subject peoples was enlightened and salutary, but the picture painted by early propagandists persisted long after the situation had in fact been changed by the activities of the propagandists themselves. The white race has, in general, behaved quite as well towards the coloured races as one man behaves to his neighbour in private life. True, in Australia and North America the aboriginal inhabitants have been vastly reduced in numbers, and have gained little if anything from the coming of the white man, but in New Zealand and in India the story has been vastly different. In less than two hundred years, the British made it possible for India to support four times its original population; they engineered the largest irrigation schemes in the world, they built railways which minimized the danger of local famine, they founded hospitals and universities, and they established peace, for the first time in recorded history, over the whole of the great sub-continent with its variety of races and languages. If it is urged that the reduction of infant mortality and the suppression of local wars resulted in great increase in population and not in a corresponding improvement in the standard of living, it should be remembered that the British are being condemned for actions which were at least generous in their intention. No other nation anywhere in the world has ever done a tenth as much. And yet, in 1947, millions of people in Britain were ashamed of the British record in India; and their shame arose from the persistence of an attitude which had long since served its purpose. It may well be that the British decision to withdraw from India was wise and timely: India in 1947, through the rapid growth of population, was becoming a liability too heavy for a nation which twice in thirty years had fought a five years' war; but there is no doubt that the decision was greatly influenced by a radically mistaken attitude. It may happen, it sometimes does happen, that an outworn attitude may give rise to decisions which are in fact extremely profitable, but accidents of this kind do not provide a good permanent basis for national policy.

In international affairs, the time-lag between the facts of the

day and the opinion of democratic nations is no less alarming. The French, who in 1800 formed 17 per cent of the population of Europe, have never wholly accepted the fact that they are now less than 8 per cent, and actually less in numbers than the inhabitants of Brazil. The Russian Government, throwing away one of the major advantages of an oligarchy over a democracy, persists in an attitude of fear and suspicion which was appropriate enough in 1917 but was insane in 1945 when the people of the free countries were overwhelmingly sympathetic to their heroic ally. Errors on this scale can do more than precipitate wars which involve a real clash of interests: they may even precipitate the wrong wars, wars in which there is no conceivable gain for the victor. There is little doubt that the willingness of the Polish people to accept war against a great nation in 1939 owed a great deal to the memory of their successes against a weak and divided Russia in 1920. The Balkan wars of 1912 and 1913 were precipitated by racial animosities which took no account of the real interests of the countries. The world to-day faces the danger of new and greater Balkan wars in which the real problems of the day will be forgotten until they impress themselves with crushing force on the exhausted and impoverished nations.

There is no new land to plough, and the land already ploughed can scarcely feed the present population of the world. That is the cardinal fact which should govern political thought to-day. The forests and plains of Brazil, the unploughed prairies of the Argentine, the irrigable land of Central Asia and the Middle East, these will scarcely make up for the land we are destroying through reckless cultivation; and yet the attitude of a century ago, when there was new and fertile land in temperate climates only waiting for the settler, still dominates the mind and hearts of men. Governments, trade union officials, industrialists and ordinary citizens still base their hopes and plans on an expanding economy, and devote their energy to fighting to a bitter end the battles that should have been fought half a century ago or never fought at all.

Quarrels of Our Own Time

As the warfare of the working classes against the rich becomes less productive, the working classes turn to war against one another. If they cannot demand a bigger share of the profits because there are no profits, they can still demand higher wages and, by pushing up the cost of their own commodity, they can reduce the standards of living of the community at large. If the miners in a nationalized industry gain an increase in wages without increasing their output, they are robbing the steel workers, the shop assistants and the farm labourers, and when the time is ripe, these will retaliate.

The struggle is not necessarily idiotic: it is a slow, complicated and painful method of measuring the relative demand for different kinds of labour; and because the needs of society are exceedingly complex it may, in fact, be a quicker and less painful method than dictatorial decision by a planning authority. Some needs are so intricate and so variable, that a whole army of observers and statisticians could not keep their figures up to date; and other needs, though less intricate, would still be so difficult to assess that the cost of the assessment would be prohibitive. A nation cannot afford to employ a thousand skilled mathematicians to assess the exact day-by-day value to the community of a professional footballer, a semi-skilled rat-catcher in Caithness or a music-hall comedian like Danny Kaye. If a country is to have a National Wages Policy, its Board of Assessors must not cost more than they are worth, and must not waste their time on unprofitable problems. The Policy must be rough and ready, and if demand and the national need are to be criteria influencing wages, some complicated needs and variable demands must be left outside its purview. Even if the general distribution of wages and salaries is fixed through a National Policy, there will still be room on the margin for economic strife in the broadest sense—including competition not only for ordinary money but also for secondary monies such as building priorities, travelling permits, petrol coupons, special

ration tickets and supplementary breathing licences. A sound National Policy, loyally accepted by the mass of the people, or strongly backed by the judiciary and the police, could minimize the area and intensity of these quarrels: it could not eliminate them.

At best, a National Wages Policy would suffer the disadvantages of all forms of National Planning: it would be cumbersome and inefficient in detail; it would substitute occasional major blunders and disasters for the day-to-day failures and stoppages of the competitive society to which our trades unions are attuned; it would weaken the sense of *individual* responsibility and enterprise on which a society sometimes depends in time of crisis. At the same time, it would have the virtues of its vices: it would avoid the shocking waste involved in prolonged and paralysing strikes and lock-outs; it would direct attention to the general need to increase the size of the national cake rather than snatch someone else's share; and the main direction of the national effort would be determined by a smaller (and, one hopes, more far-sighted) group than the general public or the wandering investor. No doubt there would be wire-pulling, block-voting and backstairs bargaining, and occasionally the Board of Assessors would intentionally cripple some important industry by making it unattractive to all except the enthusiast or the half-wit, but a National Policy could at least prevent the quarrels between cotton worker and miner, steel worker and farm labourer, from involving a whole country in a vicious spiral of strikes, inflation, reduced output, more strikes and more inflation.

To succeed, without the backing of force (which is itself an unproductive use of labour) the Policy would need the backing of public opinion. The doctrine that a craft is worth what it can get out of the community would have to be abandoned. In the abstract, we are all willing to recognize the need for more than one type in society: in a civilized society, the farmer and the scholar, the hero and the saint, are no less necessary than the mechanic and the statesman. The problem—and it is not an easy one—is to turn esteem into assessment, and to accept a

state of affairs in which for the vast majority of people any improvement can come only through a general increase in output.

There are some cardinal principles which any far-sighted Board of Assessors would be likely to accept. Any well-regulated state, whether democratic or oligarchic, gives adequate rewards to its soldiers and its judges, its police and its teachers. If any of these four groups are persistently underpaid, a poison is generated in the body politic:[1] the group gradually loses its high devotion to an impersonal ideal; it begins to see itself as a political force, it becomes partisan in its decisions, and begins to look forward to the day when power will pass from the existing government into its own hands and that of its friends. Selfless devotion will persist through a long period of ingratitude and neglect, but they will not persist indefinitely. A far-sighted Board of Assessors, if it wishes to preserve the stability of the state, will see that these vital groups are adequately rewarded in money or respect or privilege.

Again, to a centralized state, the devotion of its civil servants is vital, and it is equally vital that the service should attract men and women with energy and ability not less than that of the private citizens with whom they have to deal. If, as seems likely, the world is going to suffer from a shortage of high ability, it will be all the more necessary to make the career of the civil servant as attractive as possible. Similar difficulties will arise in the recruitment of doctors and surgeons, and one of the ancillary problems which will have to be tackled in conjunction with the problem of pay and privilege is that of the cost of entry to the professions. Still more important, no modern society can afford to neglect its scientists, for the penalty is economic stagnation in time of peace, and defeat in time of war. Finally, the claims of the artist, the philosopher, the architect, poet and musician, must be considered. In the past, these groups have always been supported by a wealthy and leisured minority: it is

[1] The mistake of under-paying the ordinary teachers was made by the Conservatives in England for many years, and was one cause of the drastic political change of 1945. The same mistake is now being made in the U.S.A.

by the achievement of these groups that we measure the vitality and dignity of the civilizations of the past: where literature and the arts have declined, military and economic decline have followed. But to-day, there is little sign that the masses would offer direct support to writers or artists of any real merit: the people prefer to offer immense rewards to film-stars, boxers and strip-tease artists, whom they pay more highly than they pay their own political leaders.

If the democratic societies, in spite of their inertia, vulgarity and greed, possess real vitality, they will find some means by which their administrators and professional men can take over, officially or unofficially, the responsibilities once exercised by the wealthy patron of the arts.

We have said nothing of the work of the National Wages Board in relation to the claims of factory workers, miners and farm-hands, for in principle the claims of these sections of society can be considered in terms of short-term needs. If a country chooses to plan its production of cotton goods five years ahead, it should be fairly easy to calculate how many workers must be attracted into the industry or how many must be driven out, and then to decide what rate of wages will effect the necessary change. In practice, the task will be incredibly difficult. Every industry represents an immense vested interest; the ordinary worker is intensely reluctant to share with the general public any improvement in his own productivity, even if that improvement is the result of scientific inventions in which he played no part: if the process of sharing the benefit means that he must uproot himself and learn a new trade, he will use every means at his disposal to preserve the *status quo*. The utmost to which he will consent is a restriction of new entries to the trade, and he will insist that it is iniquitous that an increase in productivity should result in a lowering of wages. In the extreme case, in which the invention of a cheap and satisfactory substitute for his own product makes his whole industry redundant, he will demand that the new process be forbidden. He may even come to see that although the community as a whole may benefit from a new industrial discovery, the ordinary worker in that industry

is more likely to lose by it: he will then oppose, perhaps with violence, any further research.

Change, even change for the better, is painful: under capitalism, the suffering and insecurity resulting from technical progress were distributed in one way; under fascism or communism they are distributed in another way. In both cases, the majority benefits and a minority is thrown out of employment, or receives lower wages, or is forcibly transferred to some other industry and perhaps some other district. The problem of a state which respects the individual and sets a high value on justice is to distribute the suffering as evenly as the rewards. In the long run, this can be done only if wages are determined by some process other than warfare by strike and lock-out; and for that reason the trade unions will, in the course of time, offer to abandon their old weapons, though not until progressive trade union leaders have fought a tough battle with conservative rebels, who —calling themselves communists—refuse to allow a national problem to be tackled in a national way, and offer to die in the last ditch in defence of the classical methods of industrial bargaining.

For many years to come, the restrictive habits which grew up under the fear of unemployment are likely to be encouraged by the very natural dislike of change, even when profitable alternatives are offered, and this factor, far more than the conservatism of the employers, will restrict the rate at which industrial productivity can be increased. In this way, the conservatism of the workers will accentuate the difficulties arising from the growing disequilibrium between the world's population and its available supply of food and raw materials. Only through suffering, and perhaps through hopeless violence, will the world learn to direct its labour into those channels where it is most needed: the function of a National Wages Board would be to clarify the issues, and to cut short the period of struggle by proposing from the beginning the solution which would, in fact, have to be accepted at the end of the struggle.

The Revolt of the Sub-Men

The crisis of industrial warfare has not yet been reached. The

early stages of industrialism still offered ample scope for the unskilled worker. The intelligent citizen could invent the new machine and direct its use, the dull-witted could feed the machine and do the mechanical jobs which were a little too complicated for the equipment in use. But more and more the dull-witted worker becomes redundant—it is cheaper, in terms of the final cost in food and raw material, to make a new machine to do his work. The world has less and less use for the workers whose intellectual category is D and E, and there is more and more demand for the A's and B's.

Meanwhile, there is a tendency, both in Europe and America, to accentuate the difference between the upper and the lower groups. The disappearance of the old class distinction based on inherited wealth is being followed by a new class distinction based on intellect, character and training. We are breeding, on the one hand, a responsible, far-sighted, energetic class which includes the engineers, the skilled mechanics, the professional labour leaders, the statesmen, scientists and higher civil servants vitally necessary to our civilization. We are also breeding (and breeding still faster) a class of irresponsible, spoon-fed, short-sighted inferiors who do work that could be done more cheaply and more accurately by any self-respecting donkey-engine or calculating-machine, and enjoy the amusements which call for no talents beyond those of the Cheshire cat. Democracy, in such circumstances, becomes a mockery: the logical form of government is that of the Communist Party in Russia or the Nazis in Germany; and the danger is that the intellectually inferior class will accept the implication but try to reverse the roles of governor and governed.

It would be bad enough if any large section of humanity came to be regarded as sub-human inferiors, to be entertained and treated kindly, as an Englishman treats his dog, but not to be entrusted with any major decision. It would be worse, in the long run, for everybody, if millions of dull-witted machine-minders, film-fans and dog-race addicts were to tyrannize over their more intelligent fellow citizens. In a clumsy, half-hearted and sporadic fashion they will, of course, attempt to do so. They

will attempt to enslave the doctors, teachers, engineers and civil servants as some insect communities make slaves of other insects. They may not want to be educated, but they will want to be sure that no one else is educated; they may have no clear objective in life, but they will insist that the doctor shall preserve their life on such terms as they choose to pay; they may not understand the sciences, but they will grasp the advantages of living on someone else's labour.

It would be cruel and not wholly honest to interpret the changes which have occurred in Britain since 1945 in this fashion; and in any case the ambitions we have just described are precisely the ambitions of the wealthier classes of the early nineteenth century; but it is futile to deny that socialist policies receive some support from motives which are best described as inverted Fascism. A political leader has to take the rough with the smooth when he looks at his followers; and the trouble is that as the need for sub-normal workers decreases, those sub-normal workers will insist more and more loudly on their right to live as parasites on the rest of the community. If they so increased in numbers that they outnumbered the rest, or if they could carry the middle 40 per cent with them against the A's and B's, they might well score considerable victories until the A's and B's developed new methods of resistance, or until the whole system collapsed like a hive overrun with drones.

It is this issue—the right of the redundant, low-grade worker to go on living and reproducing his kind in a world to which he contributes far less than he receives—which looms beyond the coming clash between rival unions each asking for a bigger share of the national income. The present tendency of the people of western Europe—and before long it may be a tendency in the United States, too—is to concede that right, and to obtain the necessary real wealth by reducing the incomes of the professional classes. The critical question is whether that sentiment will survive in face of the greater problems which confront the whole world. Liberal sentiment thrived on an expanding economy; in an economy which is stationary or which is expanding less rapidly than before, attitudes may become harder, respon-

sibilities may be stressed as heavily as rights, and the duty of the citizen to contribute efficiently and effectively to the common good may come to be regarded as a moral principle no less obvious than the duty of a state to see that its citizens are adequately clothed and fed and housed. If opinions once begin to harden in this way, the sub-normal will have to fight a long and difficult battle in defence of their privileged position, and on a short-term view the battle will not be utterly hopeless, for they can look for allies among nations and races which are economically backward.

The Quarrels of the Future

Between 1800 and 1949, the area under cultivation was doubled, and the production of food was more than trebled. The quantity of wool produced was multiplied by ten or fifteen, the quantity of cotton by twenty, and the output of coal and iron by seventy or eighty. At the end of the period, although the world's population had been trebled, people were on the whole better fed, better clothed and better housed than they had ever been before; but the process of industrial and agricultural expansion cannot continue at the same rate. We are in sight of the last expansion of agricultural land, and at present we are destroying fertile land through erosion about as fast as we are bringing new land into cultivation. If the number of people in the world continues to increase at the present rate, the world will have to accept a lower standard of living.

For every area, at a given stage of mechanical development, there is an optimum population which depends on the skill and social discipline of the people concerned. Below that limit, the life of the settler is hard for lack of co-operation; above that limit land is scarce and there is not enough food to go round. Countries like Britain and Belgium are already over-populated: they can live only by selling the products of their skill to the under-populated countries. Countries such as India and China would be over-populated if only they had the skill to enable one man to do the work of two: for them, a higher standard of living must mean a reduction of population. The United States is very

near the point at which any further increase in population must result in lower standards of consumption. In Africa, South America and parts of Australia there is room for expansion, but only under conditions of climate which will almost inevitably lead people to be satisfied with less work and less reward than that to which the inhabitants of the temperate zones are accustomed.

Almost instinctively, the people of western Europe and North America have seen the danger, and they have slowed down the expansion of their population to keep pace with the slower expansion of food and power and industrial products. The people of south-eastern Asia have done no such thing. Between 1931 and 1941, the population of India increased by 50,000,000—an annual rate of 1·4 per cent. In Java, Formosa, the Philippines and Siam the increase was still more rapid. A population greater than that of Holland and Belgium combined is being added to the world every year; and in Asia alone the increase in the next ten years will be as great as the whole present population of the United States.

How are these people to be fed? Certainly not from the produce of their own countries. The mechanization of their agriculture offers no solution. Indeed, it will make matters worse, for mechanization saves labour (or substitutes one kind of labour for another); it does not create land. The total agricultural produce of India, China and the Philippines, in the present state of tiny holdings and abundant labour, is probably very nearly a maximum. If more wheat and rice are wanted, they will have to come from elsewhere. The over-populated countries will cease to export food (many of them have done so already), they will try to compete with Europe and the United States in the sale of industrial products, they will sell all they possess to buy food from Australia or Brazil or the Argentine. And none of these measures will be adequate. Side by side with the relatively high standard of living of North America, western Europe and the British Dominions of the Southern Hemisphere, there will be hunger as bitter as the world has ever seen.

The answer can scarcely be foreign war: desperately over-

populated countries lack the margin of wealth on which military power subsists. Japan had a better chance of success in aggressive war than India or China, and yet failed. The answer is more likely to be internal war, war between north and south China, war between India and Pakistan, war between one village and another, war which will paralyse transport, destroy sanitation, monopolize medical services, and bring about those conditions of acute famine and pestilence which will restore the level of population to something compatible with the agricultural resources of the landscape.

The wars will be fought for all sorts of ideological motives, and with all sorts of weapons—actual invasion may play little part in them—but the effect will be a reduction of population.

The root of the difficulty in these countries is that Western civilization has taught them a little about the increase in production and a great deal more about health and civil order; it has lowered infant mortality and deaths through violence and removed the old checks on population without substituting new ones. If new measures are not taken to check the growth of population, the old ones will reinstate themselves, and the primitive forces that work through hunger, frenzy, bitterness and hatred of one's fellow men will undo the work of generations of British, French, American and Dutch doctors and engineers.

The infected area will reach far beyond the borders of south-eastern Asia. Some of the Central American republics are already facing similar problems; the fertile land available in the valleys is all in use, and cultivation has been pushed further and further up the mountainsides with a poorer and poorer return for the labour expended, with a resultant lowering of the general standard of living. Only one-third of the great area of the U.S.S.R. is really cultivable land, and the absorption of overcrowded countries in eastern Europe, with their high birth-rate, will do nothing to ease the problems which Russia will have to face if her population continues to increase faster than the area under cultivation. Given sufficient capital, there is land available for cultivation in the Middle East, and although it is not very extensive it is attractive in that it holds much of the world's

diminishing reserves of oil. Western Europe already holds its optimum population, but it could hold more if Russian standards of living were accepted. Australia is still half empty, but the Australians will resist the incursion of races with a lower standard of living than their own because they feel that two different standards cannot long continue in one country: the lower will always drive out the higher if there is no rigid political and economic discrimination. In South Africa a majority of the white settlers (who form only 21 per cent of the whole population) already fear that a native population with a low standard of living will tend to produce a poor-white class with the same standards unless firmly held in place. Italy, with a birth-rate which defeat has left unchecked, must envy Britain, France and Belgium the scope for colonial development which still remains to them in Africa. The lower grade of workers in western Europe, who feel obscurely that their own community has no great need of them, must turn an interested eye to Russia whose standard of living, if applied to their own countries, would, at least for some time, be compatible with their own continued existence.

The trouble about most aspirations for peace and universal brotherhood is that they are based on the assumption that the present ratio of resources to population, and of one population to another, will remain unaltered. The idealists assume that it is possible to abolish pestilence and lengthen human life without increasing the pressure on the means of subsistence. They assume that war can be avoided simply by international conventions. They do not face the fact that war is one method of adjustment to changes which they themselves have advocated and helped to bring about. They do not offer any realistic alternative to war; they say that war must be avoided at all costs, but they do not ask themselves whether they would be willing to accept a progressive lowering of their own standards and a progressive surrender of their own territories to more prolific races. They do not even ask whether such a policy is possible; they live in a cloud-cuckoo land in which the world's area goes on expanding indefinitely, and the estate of each individual is undiminished

by the multiplication of his fellows. Their outlook is the outlook of an era in which all problems of population could be solved by the settlement of new territory, and in which their own race happened to be the one that was expanding fastest.

Unrealistic pacifism can only lead to war: the pacifists themselves are not really willing to face the degradation and extinction of their race, their outlook and their way of life in the interests of peace. Their pacifism or isolationism may tempt others to risk war with them; it will not prevent them from resisting when the threat translates itself to embargoes, loss of markets, bombs and infiltration. It is no use for the pacifist to demonstrate that coloured people and whites can live side by side, or to say that the existence of communist or fascist states in one part of the world is compatible with the existence of socialist or capitalist democracies eleswhere. The real problem is dynamic, not static; it arises from economic geography, not from political ideology. The ideologies are only the channels through which the vital forces make themselves felt: they are rationalizations of deeper impulses of self-preservation. It is with the fear of hunger and the fear of racial and cultural extinction that we must deal if we want to avoid war.

The quarrels of to-morrow will be bitter and confused: bitter, because the issues will be strictly vital; confused, because the conscious motives will bear little relation to the real causes. A world which still believes that the possibilities of science are infinite, and that the world has endless reserves of coal and oil and cultivable land, is not likely to think clearly about the problems arising from the scarcity of these commodities. Within a century or so, the world's population will almost certainly be stabilized at something like three thousand millions, which is the utmost that the earth is likely to be able to feed; but before that stabilization occurs, there will be desperate struggles to decide which types of person are to survive, which races are to hold their own, which are to expand and move into new territory, and which are to dwindle and die. The struggle is inevitable; but some forms of struggle are less extravagant and painful than others, and to-day the world still has the choice of weapons.

APPENDIXES

APPENDIX A

The following are not formal summaries of the two final chapters, but notes of a few of the points that were going to be considered.

CHAPTER VIII. TYPES OF WARFARE

Inevitability of War

The forces that determine the struggle for survival of races, systems, government and ideas. People will always fight at a pinch—and rightly. Voting doesn't measure the intensity of feeling or the energy and skill of the voter. Superiority of weapons that kill at a distance, sensitive man doesn't see the results.

Atomic Bomb, etc.

Effect on civil wars and wars between small nations. War in India. Who will step in and clear up the mess?

The Strike

The effect of hunger-strikes and stay-down strikes of miners depends on moral sense of community and feeling of compassion for strikers. No one would call off anti-malarial measures just because the mosquitoes staged a sit-down strike.

Rewards and Punishments

(a) Capitalism offers freedom to starve.

(b) Colonial administration. Bribe chiefs with O.B.E. or threaten to depose and 'liquidate' them? Increased rewards encourage one section of community to multiply (same effect whether system is socialist or capitalist. Excessive fall of miners' birth-rate).

APPENDIX A

Birth Control

Modern method of extermination not war but birth control.

(a) Differential Birth-rate among nations.

(b) Differential Birth-rate among classes.

Whom do we wish to exterminate (and how can we do it)? What nations or classes tend to exterminate themselves?

Principles of Economic Warfare

Methods: (a) Deprivation. (b) Deliberate disturbances, e.g. financing disruption, capital development. Russian wheat in 1930. Application to India and China (and selected classes at home).

Ideological War

Producing a disloyal element by propaganda.

Sabotage to which complex states particularly vulnerable.

CHAPTER IX. THE ESTATE IN PROSPECT

Are We Heading for Disaster?

Has man's material power outstripped his moral development? (Science is cumulative, moral wisdom is not, or not so clearly.) Neglect of morality as a source of strength. Power and continence.

Man needs a period of stability, and in one direction (size of population) stability is about to be forced on us.

Who will Inherit the Earth?

Will the upper limit to population be imposed through war and starvation, or will it be accepted willingly?

The Moral Issue

Are we morally bound to use (a) our natural resources, and (b) our skill, to help the weak and the handicapped? If so, to what extent? Certainly not to the point at which it leads to a

positive deterioration of the race or leaves the next generation poorer than it would have been if we had followed a sterner policy.

The Division of Labour and Resources

Limitations imposed by climate. Which kind of people where? What social structure? Local standards of living.

The Material Standard

Probable horse-power per person depends on population. U.S.A.'s difficulty in raising national income higher (Markham). Stability again. Who keeps Britain poor? Restrictive practices (natural in leading nation? Will U.S.A. be driven to them?). British and American balance of trade. The good life.

The Measure of Wealth

If the passion for material possessions is not to wreck the world we must know (at any rate instinctively) what kind of civilization is attainable and is worth having. Is the standard to be quantity or quality? Some standards are self-destroying. (? Abstract justice or usefulness to the State.)

Man's psychological satisfaction essential. (The quality of the residual dissatisfaction which comes from our apprehension of perfection and of our own imperfection.) We must learn to live in harmony with the earth, as farmers, not miners.

'The waste remains, the waste remains and kills.'

Man has been at war with nature and therefore at war with one another. Harmony with nature, then harmony with our neighbours. War springs from disequilibrium.

We are being forced back to a harmonious relation with the soil, and that relation will solve our spiritual as well as our material problems. What ought *we* to do?

Stevenson on all life narrowing down to one mortal career. So too for our race. Possibilities various, but we must choose, and having chosen, give effect to our choice.

APPENDIX B

In these tables n.a. stands for not available, a dash for nil, or negligible, and a query indicates that it has not been possible to get more than an approximate figure.

TABLE I

CONTINENTAL SHARES IN WORLD PRODUCTION[1]

	Food		Fibres		Forest Products	
	1934–8	1947–8	1934–8	1947–8	1937	1947
	%	%	%	%	%	%
Far East	35	33	42	33	9	7
Europe (exclud. U.S.S.R.)	33	25	8	9	40	25
United States and Canada	18	25	29	34	48	64
Latin America	8	10	9	11	2	3
Australia and New Zealand	2	3	3	4	0·1	0·2
Africa and Near East	4	4	9	9		
	100	100	100	100	100	100

[1] F.A.O., *The State of Food and Agriculture*, 1948.—*J.R.*

TABLE II

WHEAT: AVERAGE ANNUAL PRODUCTION

(in million bushels)

Period	U.S.A.	Canada	Australia	Argentine	Russia	World
1901–05	649	87	51	105	656	3,236
1906–10	684	130	70	157	688	3,410
1911–15	802	227	94	190	811	3,872
1916–20	783	219	107	170	606	3,380
1921–05	829	369	128	205	473	3,669
1926–30	862	436	155	231	837	4,416
1931–05	676	321	168	231	934	4,700
1936–40	796	364	162	230	1,300?	6,060
1941–05	987	376	132	208	1,100?	5,950
1946	1,153	414	117	206	780	5,580
1947	1,367	342	220	245	850	5,550
1948	1,288	393	190	191	1,025	6,275
1949	1,146	367	217	210	1,100	6,236

APPENDIX B

TABLE III

NET EXPORTS OF WHEAT AND FLOUR

(in million bushels per annum)

Period	U.S.A.	Canada	Australia	Argentine	Russia
1901-05	150	32	19	67	154
1906-10	122	56	38	100	152
1911-15	160	141	40	93	102
1916-20	237	140	75	101	0?
1921-05	194	266	90	124	9
1926-30	154	295	86	155	22
1931-05	58	217	134	146	33
1936-40	39	175	97	119	18
1941-05	3	293	49	84	0
1946	362	251	57	53	n.a.
1947	495	231	53	82	n.a.
1948	493	201	130	81	32
1949	361	251	124	64	41

TABLE IV

LIVESTOCK (in millions)

	U.S.A.		Canada		Australia[1]	
	1900	1948	1900	1948	1900	1948
Cattle	60	78·1	5·4	8·3	8·6	13·8
Pigs	51	55·0	2·3	4·6	·95	1·3
Sheep	48	34·8	2·5	2·2	70·6	102·6

APPENDIX B

TABLE V

LAND USE (in million acres)[1]

	Total Area	Agricultural Area			Forests	Waste-land and Other	Population	
		Total	Arable	Per-manent Meadows and Pastures			Total	Agri-cul-tural
							m.	m.
Europe	1,218	613	368	245	306	299	387	128
North & Central America	6,000	1,636	593	1,043	1,829	2,535	210	66
(Nth. America)	(5,308)	(1,297)	(519)	(778)	(1,606)	(2,404)	(160)	(32)
(Cent. ,,)	(692)	(339)	(74)	(266)	(223)	(131)	(50)	(34)
South America	4,391	1,053	205	848	1,715	1,623	105	63
Asia	6,592	1,470	813	657	1,151	3,971	1,248	874
Africa	7,307	1,685	427	1,258	2,073	3,548	193	143
Oceania	2,115	959	45	914	79	1,077	12	4
U.S.S.R.	5,503	862	556	306	1,552	3,089	197	100 (est.)
Total	33,126	8,278	3,007	5,271	8,705	16,143	2,352	1,377

[1] F.A.O. monthly bulletin, January 1950.—*J.R.*

TABLE VI[1]

CULTIVATED LAND (in million acres)

Year	U.S.A.	Canada	Australia	Argentina	U.S.S.R.
1900	414	30·2 (1901)	9·8	n.a.	252·0 (1913)
1910	478	48·7 (1911)	14·8	n.a.	271·2 (1928)
1920	503	70·8 (1921)	19·1	n.a.	321·5 (1932)
1930	522	85·7 (1931)	30·5	45·2	318·7 (1935)
1940	530	92·4 (1941)	30·6	43·6	387·9 (1941)
1945	512	n.a.[2]	27·5	32·8	n.a.

[1] For U.S.A. and Canada, figures give total 'improved land'; for Australia, figures include artificially sown grassland (5·2 million acres in 1929–30, 9·5 million acres in 1940–1); for the Argentine, the figures include only land under wheat, oats, maize and linseed.

[2] The figure for 1950 is about 96 million acres.—*J.R.*

APPENDIX B

TABLE VII

YIELD OF WHEAT

(in bushels per acre)

Year	U.K.	Germany	U.S.A.	Canada	Australia	Argentina	U.S.S.R.
1901–15	32·7	29·5	14·6	19·5	10·1	10·3	10·0
1916–30	32·6	27·3	13·9	16·2	11·7	11·5	9·9
1931–45	33·6	33·0?	14·8	14·1	12·5	12·8	12·0?
1946–49	35·9	n.a.	17·1	15·3	13·5	17·2	10·8

TABLE VIII

U.S.A. TIMBER[1]

(in millions of board feet)

Type of Wood	Annual Saw-timber Growth on Commercial Forest Land (1945)	Annual Cut or Destruction (1944)	Excess of Loss over New Growth (1944)	Total Stand Remaining (1944)	Duration of Supplies (Years)
Softwoods	21,848	35,591	13,743	1,296,377	95
Hardwoods	13,453	14,067	614	304,595	500
Total	35,301	49,658	14,357	1,600,972	114

[1] *Statistical Abstract of the U.S.A.*

APPENDIX B

TABLE IX

KNOWN RESERVES OF PETROLEUM
(in million barrels)

	Proved Oil Reserves (at 1st Jan. 1949)	Annual Production 1949	No. of Years Reserves will be Used Up at Present Rate of Production
U.S.A.	28,000	1,840	15
U.S.S.R.	4,200	211	20
Kuwait	10,950	90	122
Venezuela	9,000	457	20
Persia	7,000	206	34
Iraq	5,000	29	172
Saudi Arabia (inc. Bahrein Islands)	9,000	176	51
Others (inc. Mexico and N.E.I.)	5,172	343	15
Total	78,322	3,352	23

TABLE X

ANNUAL PRODUCTION OF OIL IN MEXICO

Date	Million Barrels	Date	Million Barrels	Date	Million Barrels
1900	0	1918	63·8	1933	34·0
1901	·010	1919	87·1	1934	38·2
1902	·040	1920	163·6	1935	40·2
1903	·075	1921	193·4	1936	41·0
1904	·126	1922	182·3	1937	46·7
1905	·251	1923	149·6	1938	38·3
1906	·502	1924	139·7	1939	42·8
1907	1·005	1925	125·5	1940	44·0
1908	3·933	1926	90·4	1941	43·8
1909	2·7	1927	64·1	1942	34·6
1910	3·6	1928	50·1	1943	34·8
1914	25·0	1929	44·7	1944	38·2
1915	32·9	1930	39·5	1945	45·0
1916	40·5	1931	33·0	1946	50·9
1917	55·3	1932	32·8	1947	53·4
				1948	56·0
				1949	58·0

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TABLE XI

CRUDE PETROLEUM PRODUCTION

(average annual production, in million barrels)[1]

Period	U.S.A.	Venezuela	Iraq	S.Persia	Mexico	U.S.S.R.	Rumania	World
1921–25	648	7·3	—	25	156	40	12	945
1926–30	896	96	·6	41	54	94	32	1,318
1931–35	889	128	7.3	52	36	167	56	1,460
1936–40	1,242	184	28	72	43	203	50	2,010
1941–45	1,536	227	24	85	39	218	35	2,355
1946	1,731	389	35·3	146·4	51	166 2	32·2	2,888
1947	1,856	425	34	155	53	172	28	2,973
1948	2,051	469	24	192	56	185	21	3,410
1949	1,874	457	29	206	58	211	31	3,386

[1] Based on statistics of the U.S. Bureau of Mines.

TABLE XII

MIDDLE EAST PRODUCTION OF OIL

(in million barrels)

Year	Iraq	Persia	Saudi Arabia and Bahrein Is.	Kuwait	Total
1941	13	51	12·7	—	76·7
1942	20	72	12·6	—	104·6
1943	25	75	12·8	—	112·8
1944	31	102	14·5	—	147·5
1945	34	129	28·6	—	191·6
1946	35·3	146·5	67·9	5·9	251·6
1947	34	155	101	16	306
1948	24	192	154	47	467
1949	29	206	186	90	511

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TABLE XIII

OUTPUT OF ELECTRICAL ENERGY

	Total Output in 1948 in Million kw.h.	Annual kw.h. per Head	Equivalent Steady h.p. per Hour per Head
Canada	44,568	3,460	·529
U.S.A.	282,689	1,929	·295
Great Britain	46,536	972	·149
Italy	22,692	496	·076
France	27,564	671	·102
U.S.S.R.	63,000	323	·050
Argentina	3,348 (1947)	208	·032

TABLE XIV

COAL OUTPUT PER ANNUM

(in long tons per head of total population)

	1900	1910	1920	1930	1940	1948
Great Britain	5·45	6·31	5·83	5·43	4·77	4·23
United States	3·49	4·87	5·53	3·88	3·47	4·02
U.S.S.R.	0·13	0·18	0·08	0·30	0·94	0·98
World	0·46	0·62	0·70	0·62	0·66	0·62

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